Info from Official Appraisal Folders stored in R10 FM office file cabinets

2003-2018 TimberSales (1000+ MBF)	Sale#	Advertised Date	Awarded
Last Twin Reoffer	03241	5/1/2003	Y
Twin Bridges II	03255	6/21/2003	Y
South Lindy Mountain Resale	03223	7/17/2003	N
Orion South	03259	7/21/2003	Y
Grey Ghost Cedar Salvage Reoffer	03248	7/28/2003	N
Luck Lake	03269	8/16/2003	N
Fusion	03270	9/25/2003	Y
Situk Blowdown Reoffer	40556	10/9/2003	Y
Thorne Island	04088	4/3/2004	Y
Orion North	04052	4/10/2004	Y
Luck Lac	04096	6/11/2004	N
Finger Point	04092	6/17/2004	Y
Licking Creek	04091	8/6/2004	Y
Midway Reoffer II	04106	9/23/2004	Y
Drumlin	04113	9/25/2004	N
Kogish Shinaku	04103	9/30/2004	Y
Boundary	04118	9/30/2004	N
Shady	05038	3/31/2005	Y
Coyak Salvage	05074	4/11/2005	Y
Luck Lac II	05098	7/29/2005	Y
Doughnut	05082	8/4/2005	N
Lindenburg	05112	9/29/2005	Y
Skipping Cow	05083	9/29/2005	Y
Upper Carroll II	05092	9/29/2005	Y
Buckdance Madder Reoffer	05054	1/31/2006	Y
Red Mountain	06074	2/18/2006	Y
Drumlin Reoffer II	05105	4/22/2006	Y
Bluelight Special	06042	6/15/2006	N
Backline	07032	4/12/2007	Y
Tuxekan	07057	7/25/2007	Y
Scratchings	07050	8/27/2007	Y
Backline Helicopter	08031	6/3/2008	N
Baht	08040	7/18/2008	N
Overlook	07065	7/22/2008	N
Overlook Reoffer	07065	3/5/2009	N
Backline Helicopter Reoffer	08031	3/5/2009	N
Frenchie	09108	3/5/2009	N
Orion North Reoffer	08035	3/12/2009	Y
Diesel	09124	11/28/2009	Y
Slake	10024	9/11/2010	Y
Heceta Stewardship YG		1/1/2011	Y
Frenchie Stewardship	09108	1/1/2011	Y
Backline Helicopter Reoffer II	08031	3/17/2011	Y
Tonka Stewardship		1/1/2012	Y
Wabbit Stewardship	11008	1/1/2012	Y
Tower	11013	2/9/2013	Y
Zarkof Salvage	12017	3/16/2013	Y
Big Thorne Stewardship	14041	1/1/2014	Y
Dargon Point	14005	5/10/2014	N
Last Stand	14012	10/4/2014	Y
Camel Back	14015	8/22/2015	Y
Big Buck	15035	9/15/2015	Y
North Kuiu	16060	8/13/2016	N
Three Sisters	14026	9/3/2016	Y
GNA Kosciusko YG	17033	1/1/2017	Y
GNA Vallenar YG	18062	1/1/2018	Y
In Between Resale	14013	2/10/2018	N
Rough Luck	17023	3/31/2018	Y
North Kuiu 2	17010	5/7/2018	N
Wrangell Island	17001	8/18/2018	N
South Snakey	18005	8/25/2018	Y
South Snakey	18005	8/28/2018	N

Info from Official Appraisal Folders stored in R10 FM office file cabinets										
2003-2018 AWARDED Timber Sales 1000+ MBF	**Sale #**	**NMBF incl nonsaw**	**Advertised Date**	**AWARDED = Y**	**Harvest acres**	**St-Trck $**	**New Perm Rd**	**Tmp Rd**	**calc new rd miles**	**calculated % closed**
Last Twin Reoffer	03241	1314	5/1/2003	Y	22	89	0	0.45	0.45	100%
Twin Bridges II	03255	7027	6/21/2003	Y	249	170	3.09	1.44	4.53	32%
Orion South	03259	3384	7/21/2003	Y	124	151	0	0.7	0.7	100%
Fusion	03270	38623	9/25/2003	Y	1477	202	10.28	4.41	14.69	30%
Situk Blowdown Reoffer	40556	25124	10/9/2003	Y	1203	234	0	0.91	0.91	100%
Thorne Island	04088	1916	4/3/2004	Y	110	356	0	0	0	
Orion North	04052	6382	4/10/2004	Y	381	151	5.1	1.5	6.6	23%
Finger Point	04092	10490	6/17/2004	Y	296	234	1.6	2.5	4.1	61%
Licking Creek	04091	15322	8/6/2004	Y	527	126	3.1	3.17	6.27	51%
Midway Reoffer II	04106	8222	9/23/2004	Y	427	156	0	0	0	
Kogish Shinaku	04103	8026	9/30/2004	Y	290	221	0	1.47	1.47	100%
Shady	05038	4026	3/31/2005	Y	231	127	0	0.1	0.1	100%
Coyak Salvage	05074	7959	4/11/2005	Y	593	234	0	0	0	
Luck Lac II	05098	8586	7/29/2005	Y	320	346	1.17	0.16	1.33	12%
Lindenburg	05112	23239	9/29/2005	Y	715	230	1.3	0.59	1.89	31%
Skipping Cow	05083	18641	9/29/2005	Y	851	189	2.57	2.34	4.91	48%
Upper Carroll II	05092	16488	9/29/2005	Y	609	147	4.74	0.65	5.39	12%
Buckdance Madder Reoffer	05054	15425	1/31/2006	Y	647	199	0.4	5.25	5.65	93%
Red Mountain	06074	5889	2/18/2006	Y	640	398	0	0	0	
Drumlin Reoffer II	05105	1080	4/22/2006	Y	27	157	0	0.19	0.19	100%
Backline Cable	07032	4519	4/12/2007	Y	267	265	0	1.01	1.01	100%
Tuxekan	07057	8883	7/25/2007	Y	236	154	6.13	0.16	6.29	3%
Scratchings	07050	11332	8/27/2007	Y	546	204	3.77	3.26	7.03	46%
Orion North Reoffer	08035	4360	3/12/2009	Y	361	212	1.17	1.08	2.25	48%
Diesel	09124	23853	11/28/2009	Y	1165	162	2.6	11.7	14.3	82%
Slake	10024	18839	9/11/2010	Y	1403	225	1.1	10.3	11.4	90%
Heceta Stewardship YG	11029	7557	1/1/2011	Y	386	178	0	0.8	0.8	100%
Frenchie Stewardship	09108	26177	1/1/2011	Y	1137	231	0	3.1	3.1	100%
Backline Helicopter Reoffer II	08031	1751	3/17/2011	Y	237	460	0	0	0	
Tonka Stewardship	12026	36401	1/1/2012	Y	2220	234	1.4	5.4	6.8	79%
Wabbit Stewardship	11008	1314	1/1/2012	Y	78	148	0	0.7	0.7	100%
Tower	11013	1204	2/9/2013	Y	52	238	0	0.6	0.6	100%
Zarkof Salvage	12017	3452	3/16/2013	Y	110	392	0	0	0	
Big Thorne Stewardship	14041	97717	1/1/2014	Y	3819	294	3.1	13.7	16.8	82%
Last Stand	14012	1639	10/4/2014	Y	62	164	0	0.5	0.5	100%
Camel Back	14015	8444	8/22/2015	Y	389	179	0	4.7	4.7	100%
Big Buck	15035	3813	9/15/2015	Y	50	135	0	0	0	
Three Sisters	14026	9803	9/3/2016	Y	372	265	0.7	1	1.7	59%
GNA Kosciusko YG	17033	30008	1/1/2017	Y	1500	258	0	0	0	
GNA Vallenar YG	18062	2624	1/1/2018	Y	73	139	0	0	0	
Rough Luck	17023	7559	3/31/2018	Y	438	222	0.7	2.7	3.4	79%
South Snakey	18005	1752	8/25/2018	Y	91	165	0	0.8	0.8	100%
42		540164			24731	215.2619	54.02	87.34		

2003-2010	# of Sales (>1MMBF) Sold	MMBF Awarded	# TS purchasers (>3MMBF)	# log comp (>3MMBF)	calculated total companies	Acres	fell yd load $/MBF	new rd miles	calc new rd mi / mmbf harv	% new rd closed
2003	5	75	4	4	8	3075	$205	21.3	0.3	72%
2004	6	50	5	6	11	2031	$180	18.4	0.4	59%
2005	6	79	5	6	11	3319	$211	19.3	0.2	49%
2006	3	22	4	5	9	1314	$249	5.8	0.3	61%
2007	3	25	4	5	9	1049	$197	14.3	0.6	50%
2008	0	0	3	3	6	0				
2009	2	28	3	3	6	1526	$170	16.6	0.6	65%
2010	1	19	2	2	4	1403	$225	11.4	0.6	90%
AVG per year	**3**	**37**	**4**	**4**	**8**	**1715**	**$203**	**15.3**	**0.4**	**64%**
Total MMBF		299								
2011	3	35	2	3	5	1760	$231	3.9	0.1	100%
2012	2	38	2	3	5	2298	$231	7.5	0.2	90%
2013	2	5	2	3	5	162	$352	0.6	0.1	100%
2014	2	99	2	3	5	3881	$292	17.3	0.2	91%
2015	2	12	2	3	5	439	$165	4.7	0.4	100%
2016	1	10	2	3	5	372	$265	1.7	0.2	59%
2017	1	30	2	3	5	1500	$258	0.0	0.0	
2018	3	12	2	3	5	602	$195	4.2	0.4	90%
AVG per year	**2**	**30**	**2**	**3**	**5**	**1377**	**$258**	**5.0**	**0.2**	**90%**
Total MMBF		241								

2003-2010	# of TSales (>1MMBF) Sold	TS MMBF Awarded	# timber comp (operate 3-33 MMBF/yr)	1000 Acres	fell yd load $/MBF	miles new rd	new rd miles / mmbf harv	% new rd closed	annual exp / annual harv
2003	5	75	8	3.1	$205	21.3	0.3	72%	9%
2004	6	50	11	2.0	$180	18.4	0.4	59%	23%
2005	6	79	11	3.3	$211	19.3	0.2	49%	42%
2006	3	22	9	1.3	$249	5.8	0.3	61%	11%
2007	3	25	9	1.0	$197	14.3	0.6	50%	16%
2008	0	0	6	0.0					19%
2009	2	28	6	1.5	$170	16.6	0.6	65%	48%
2010	1	19	4	1.4	$225	11.4	0.6	90%	36%
AVG per year	**3**	**37**	**8**	**1.7**	**$203**	**15.3**	**0.4**	**64%**	**25%**

2011-2018	# of TSales (>1MMBF) Sold	TS MMBF Awarded	# timber comp (operate 3-33 MMBF/yr)	1000 Acres	fell yd load $/MBF	miles new rd	new rd miles / mmbf harv	% new rd closed	annual exp / annual harv
2011	3	35	5	1.8	$231	3.9	0.1	100%	51%
2012	2	38	5	2.3	$231	7.5	0.2	90%	51%
2013	2	5	5	0.2	$352	0.6	0.1	100%	22%
2014	2	99	5	3.9	$292	17.3	0.2	91%	41%
2015	2	12	5	0.4	$165	4.7	0.4	100%	23%
2016	1	10	5	0.4	$265	1.7	0.2	59%	58%
2017	1	30	5	1.5	$258	0.0	0.0		42%
2018	3	12	5	0.6	$195	4.2	0.4	90%	46%
AVG per year	**2**	**30**	**5**	**1.4**	**$258**	**5.0**	**0.2**	**90%**	**41%**

8 Years Before and After R10 Roadless Restriction in 2011 ~~jp 061319~~ improved 112219

Decreasing Trend in # of TS, Volume, Companies, Acres, & new roads / **Increasing Trend in Logging Costs and % Export**

2003-2010	# of TSales (>1MMBF) Sold	TS MMBF Sold	# timber comp (operate 3-33 MMBF/yr)	1000 Acres	miles new rd	new rd miles / mmbf harv	% new rd closed	2003-2010	fell yd load $/MBF	annual exp / annual harv
2003	5	75	8	3.1	21.3	0.3	72%	2003	$205	9%
2004	6	50	11	2.0	18.4	0.4	59%	2004	$180	23%
2005	6	79	11	3.3	19.3	0.2	49%	2005	$211	42%
2006	3	22	9	1.3	5.8	0.3	61%	2006	$249	11%
2007	3	25	9	1.0	14.3	0.6	50%	2007	$197	16%
2008	0	0	6	0.0				2008		19%
2009	2	28	6	1.5	16.6	0.6	65%	2009	$170	48%
2010	1	19	4	1.4	11.4	0.6	90%	2010	$225	36%
AVG per year	**3**	**37**	**8**	**1.7**	**15.3**	**0.4**	**64%**	**AVG per year**	**$203**	**25%**
Total MMBF		299								

Decreasing Trend in # of TS, Volume, Companies, Acres, & new roads / **Increasing Trend in Logging Costs and % Export**

2011-2018	# of TSales (>1MMBF) Sold	TS MMBF Sold	# timber comp (operate 3-33 MMBF/yr)	1000 Acres	miles new rd	new rd miles / mmbf harv	% new rd closed	2011-2018	fell yd load $/MBF	annual exp / annual harv
2011	3	35	5	1.8	3.9	0.1	100%	2011	$231	51%
2012	2	38	5	2.3	7.5	0.2	90%	2012	$231	51%
2013	2	5	5	0.2	0.6	0.1	100%	2013	$352	22%
2014	2	99	5	3.9	17.3	0.2	91%	2014	$292	41%
2015	2	12	5	0.4	4.7	0.6	100%	2015	$165	23%
2016	1	10	5	0.4	1.7	0.2	59%	2016	$265	58%
2017	1	30	5	1.5	0.0	0.0		2017	$258	42%
2018	3	12	5	0.6	4.2	0.4	90%	2018	$195	46%
AVG per year	**2**	**30**	**5**	**1.4**	**5.0**	**0.2**	**90%**	**AVG per year**	**$258**	**41%**
Total MMBF		241								

SOURCE: Timber Sale Summary Reports and Accomplishments, https://www.fs.usda.gov/detail/r10/landmanagement/resourcemanagement/

Tongass National Forest Log Exports and Interstate Shipments (MMBF)
(Compiled by Tongass NF)

Calendar Year	Destination	Sitka Spruce	Western Hemlock	Alaska Cedar	Western Red Cedar	All Species		CY exp shipment	Annual Harvest	annual exp/ annual harv
2003	Canada	0.1	0.4	0.2	0.0	0.6				
	U.S.	0.0	0.0	0.1	0.3	0.4				
	Pacific Rim	0.0	0.0	2.9	0.4	3.3				
	Total Exports	0.1	0.4	3.2	0.6	4.3		4.3	48.1	9%
2004	U.S.	0.0	0.0	0.0	1.4	1.4				
	Pacific Rim	6.8	1.2	1.7	0.0	9.7				
	Total Exports	6.8	1.2	1.7	1.4	11.2		11.2	49.2	23%
2005	U.S.	0.0	0.0	0.0	3.9	3.9				
	Pacific Rim	11.7	1.9	1.9	0.0	15.5				
	Total Exports	11.7	1.9	2.0	3.9	19.5		19.5	46.6	42%
2006	U.S.	0.0	0.0	0.0	2.5	2.5				
	Pacific Rim	0.4	0.1	0.4	0.8	1.8				
	Total Exports	0.4	0.1	0.5	3.3	4.4		4.4	40.0	11%
2007	Canada	0.1	0.0	0.0	0.2	0.3				
	U.S.	0.0	0.0	0.0	0.2	0.2				
	Pacific Rim	0.2	0.1	2.7	0.0	3.0				
	Total Exports	0.3	0.1	2.7	0.4	3.5		3.5	22.5	16%
2008	U.S.	0.0	0.0	0.3	1.1	1.4				
	Pacific Rim	1.2	1.7	1.6	0.0	4.4				
	Total Exports	1.2	1.7	1.9	1.1	5.8		5.8	30.0	19%
2009	U.S.	0.0	0.0	0.0	0.3	0.3				
	Pacific Rim	3.5	8.7	0.8	0.4	13.4				
	Total Exports	3.5	8.7	0.8	0.7	13.7		13.7	28.3	48%
2010	U.S.	0.0	0.0	0.0	0.0	0.0				
	Pacific Rim	2.5	8.6	1.8	0.0	12.8				
	Total Exports	2.5	8.6	1.8	0.0	12.9		12.9	35.7	36%
2011	U.S.	0.0	0.0	0.0	5.3	5.3				
	Pacific Rim	1.2	7.8	1.7	0.0	10.7				
	Total Exports	1.2	7.8	1.7	5.3	16.0		16.0	31.6	51%
2012	Canada	0.1	0.0	0.0	0.0	0.1				
	U.S.	0.1	0.0	0.0	0.8	0.9				
	Pacific Rim	1.4	4.6	1.8	0.0	7.8				
	Total Exports	1.6	4.6	1.9	0.8	8.9		8.9	17.5	51%
2013	Canada	0.0	0.0	0.0	0.0	0.0				
	U.S.	0.0	0.0	0.0	0.0	0.0				
	Pacific Rim	1.8	6.3	0.8	0.0	9.0				
	Total Exports	1.8	6.3	0.8	0.0	9.0		9.0	41.2	22%
2014	Canada	0.0	0.1	0.0	0.0	0.2				
	U.S.	0.0	0.0	0.0	0.0	0.0				
	Pacific Rim	3.7	9.2	1.8	0.0	14.7				
	Total Exports	3.7	9.4	1.8	0.0	14.9		14.9	36.7	41%
2015	Canada	0.0	0.0	0.0	0.0	0.0				
	U.S.	0.0	0.0	0.0	0.0	0.0				
	Pacific Rim	3.8	8.3	1.3	0.0	13.4				
	Total Exports	3.8	8.3	1.3	0.0	13.4		13.4	59.5	23%
2016	Canada	0.0	0.0	0.0	0.0	0.0				
	U.S.	0.0	0.0	0.0	2.3	2.3				
	Pacific Rim	6.1	13.6	2.9	0.1	22.8				
	Total Exports	6.1	13.6	2.9	2.4	25.0		25.0	43.5	58%
2017	Canada	0.0	0.0	0.0	0.0	0.0				
	U.S.	0.0	0.0	0.0	0.7	0.8				
	Pacific Rim	1.0	4.1	0.7	0.0	5.8				
	Total Exports	1.0	4.1	0.7	0.7	6.6		6.6	15.9	42%
2018	Canada	0.0	0.0	0.0	0.0	0.0				
	U.S.	0.0	0.0	0.0	0.5	0.5				
	Pacific Rim	1.8	6.0	0.8	0.0	8.7				
	Total Exports	1.8	6.1	0.8	0.5	9.2		9.2	20.0	46%

SOURCE: Timber Sale Summary Reports and Accomplishments, located at Webpage: https://www.fs.usda.gov/detail/r10/landmanagement/resourcemanagement/

Timber Harvested From National Forests in Alaska 1908 to Present

Tongass National Forest

Period		Sawlog MBF	Non-Sawlog MBF	Converted MBF	Calendar Year	Converted MBF	calculated CY MMBF
Oct-18	Dec-18	3,766.08	156.80	3,922.88	2018	20,007.86	20.01
Jul-18	Sep-18	5,638.13	32.26	5,670.39			
Apr-18	Jun-18	4,060.26	58.00	4,118.26			
Jan-18	Mar-18	3,899.01	2,397.32	6,296.33			
Oct-17	Dec-17	3,751.48	0.00	3,751.48	2017	15,882.05	15.88
Jul-17	Sep-17	5,041.74	30.89	5,072.63			
Apr-17	Jun-17	2,708.84	114.53	2,823.37			
Jan-17	Mar-17	4,204.77	29.80	4,234.57			
Oct-16	Dec-16	7,826.98	53.75	7,880.73	2016	43,520.80	43.52
Jul-16	Sep-16	7,193.21	2,614.50	9,807.71			
Apr-16	Jun-16	10,490.15	12.74	10,502.89			
Jan-16	Mar-16	13,669.24	1,660.23	15,329.47			
Oct-15	Dec-15	9,482.18	253.01	9,735.19	2015	59,490.49	59.49
Jul-15	Sep-15	11,772.19	136.95	11,909.14			
Apr-15	Jun-15	7,534.86	27,579.29	35,114.15			
Jan-15	Mar-15	2,674.74	57.27	2,732.01			
Oct-14	Dec-14	6,920.24	207.01	7,127.25	2014	36,650.67	36.65
Jul-14	Sep-14	14,422.41	1,474.56	15,896.97			
Apr-14	Jun-14	10,581.56	814.00	11,395.56			
Jan-14	Mar-14	1,800.85	430.04	2,230.89			
Oct-13	Dec-13	9,275.20	327.84	9,603.04	2013	41,166.75	41.17
Jul-13	Sep-13	13,476.05	6,490.50	19,966.55			
Apr-13	Jun-13	5,406.99	5,797.50	11,204.49			
Jan-13	Mar-13	366.67	26.00	392.67			
Oct-12	Dec-12	4,686.90	115.07	4,801.97	2012	17,469.63	17.47
Jul-12	Sep-12	4,448.23	273.44	4,721.67			
Apr-12	Jun-12	6,207.59	151.00	6,358.59			
Jan-12	Mar-12	1,334.40	253.00	1,587.40			
Oct-11	Dec-11	7,981.43	178.47	8,159.90	2011	31,643.13	31.64
Jul-11	Sep-11	11,487.69	300.85	11,788.54			
Apr-11	Jun-11	6,386.46	60.71	6,447.17			
Jan-11	Mar-11	5,161.01	86.51	5,247.52			
Oct-10	Dec-10	7,128.12	2,026.50	9,154.62	2010	35,650.47	35.65

		Tongass National Forest											
Period		Sawlog MBF	Non-Sawlog MBF	Converted MBF	Calendar Year	Converted MBF	calculated CY MMBF						
Jul-10	Sep-10	10,947.74	171.98	11,119.72									
Apr-10	Jun-10	7,262.76	175.55	7,438.31									
Jan-10	Mar-10	3,615.76	4,322.06	7,937.82									
Oct-09	Dec-09	8,450.98	462.90	8,913.88	2009	28,326.99	28.33						
Jul-09	Sep-09	10,352.88	910.69	11,263.57									
Apr-09	Jun-09	6,532.93	1,612.78	8,145.71									
Jan-09	Mar-09	0.50	3.33	3.83									
Oct-08	Dec-08	8,402.71	566.68	8,969.39	2008	30,001.84	30.00						
Jul-08	Sep-08	10,500.39	418.53	10,918.92									
Apr-08	Jun-08	7,968.01	1,025.07	8,993.08									
Jan-08	Mar-08	1,082.83	37.62	1,120.45									
Oct-07	Dec-07	4,492.87	2,464.13	6,957.00	2007	22,480.70	22.48						
Jul-07	Sep-07	9,352.60	1,877.52	11,230.12									
Apr-07	Jun-07	1,800.87	548.56	2,349.43									
Jan-07	Mar-07	1,024.47	919.68	1,944.15									
Oct-06	Dec-06	2,609.79	601.54	3,211.33	2006	40,044.70	40.04						
Jul-06	Sep-06	15,268.81	2,097.66	17,366.47									
Apr-06	Jun-06	8,634.57	324.63	8,959.20									
Jan-06	Mar-06	8,450.14	2,057.56	10,507.70									
Oct-05	Dec-05	6,174.70	153.15	6,327.85	2005	46,583.45	46.58						
Jul-05	Sep-05	6,820.14	970.41	7,790.55									
Apr-05	Jun-05	14,960.15	8,151.06	23,111.21									
Jan-05	Mar-05	8,472.34	881.50	9,353.84									
Oct-04	Dec-04	8,329.13	1,017.41	9,346.54	2004	49,180.43	49.18						
Jul-04	Sep-04	13,922.65	7,352.85	21,275.50									
Apr-04	Jun-04	11,462.81	1,097.99	12,560.80									
Jan-04	Mar-04	5,332.96	664.63	5,997.59									
Oct-03	Dec-03	5,997.20	605.41	6,602.61	2003	48,106.69	48.11						
Jul-03	Sep-03	27,165.85	2,881.91	30,047.76									
Apr-03	Jun-03	7,148.10	2,800.25	9,948.35									
Jan-03	Mar-03	1,322.52	185.45	1,507.97									

Contact Information

Alaska Regional Office
PO Box 21628
709 W. 9th Street
Juneau, AK 99802-1628
(907) 586-8806

Chugach National Forest
161 East 1st Ave., Door 8
Anchorage, AK 99501
(907) 743-9500

Tongass National Forest
648 Mission Street
Ketchikan, AK 99901
(907) 225-3101

Forest & Grassland Health

Yellow-Cedar Decline

Cause: Yellow-cedar decline is caused by fine-root freezing injury. It occurs on sites with shallow soils and low snowpack. Yellow-cedar is uniquely vulnerable to this form of injury compared to associated conifers.

Host(s) in Alaska:

Yellow-cedar (*Callitropsis nootkatensis* (D. Don) Oerst. ex D.P. Little; formerly *Chamaecyparis nootkatensis*

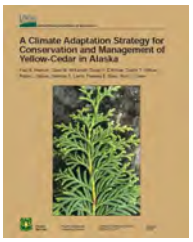
Topics

Climate Adaptation Strategy for Yellow-Cedar
Current Status & Distribution
Yellow-Cedar Decline Summary
Historic Activity
Causes of Yellow-Cedar Decline
Symptoms & Damage
Ecological Impacts
Salvage Opportunities
Decline in Managed Young-Growth
Recent Work
Distribution Map
Resources & Publications (full list)

Yellow-cedar decline, Peril Strait, Chichagof Island.

Dead and dying yellow-cedars, Peril Strait, Chichagof Island.

Climate Adaptation Strategy for Yellow-Cedar in Alaska



Several branches of the USFS (Forest Health Protection, Pacific Northwest Research Station, Alaska Regional Office, and National Forest System) worked together to develop ***A Climate Adaptation Strategy for Conservation and Management of Yellow-cedar in Alaska*** (2016). This report synthesizes the ecology, cultural and commercial values, taxonomy, and silvics of yellow-cedar; the mechanism and risk factors of yellow-cedar decline; guidance and opportunities for the active management of yellow-cedar; the development of models to estimate the distribution of yellow-cedar and the current and future risk factors for decline; and the current and projected future status of yellow-cedar in 33 management zones in Alaska.

Current Status & Distribution in Alaska (2018 Update)

NEW The US Fish & Wildlife Service decision to deny federal protection for yellow-cedar under the Endangered Species Act was finalized on October 7th, 2019. The full listing decision is available in the Federal Register (Vol. 84, No. 194). The Yellow-Cedar Species Status Assessment, upon which the decision was based, was completed in December 2018. Read more here.

In 2018, less than 18,000 acres of forest with actively dying yellow-cedar trees (trees with yellow-red crowns) were mapped during the aerial survey (see Map), down from a recent peak of 47,500 acres in 2017. This reduction in mapped acreage likely reflects a true decrease in decline activity following a colder, snowier winter, but also stems from more conservative mapping. In 2018, surveyors made a concerted effort to draw polygons tightly around areas of forest affected by decline. When surveyors draw larger polygons around affected forest and assign a lower value for the percentage of trees affected, it may inadvertently incorporate areas of forest only marginally affected by decline. Both styles of mapping are correct, but larger polygons can inflate the total area of mapped decline. Increases in overall affected acreage are expected to roughly coincide with the occurrence of decline events (early spring thaws followed by freezing conditions in the absence of snow, as occurred in 2015 and 2016). However, because trees and forests typically remain symptomatic for several years as trees gradually die, a significant decrease in mapped acreage is not expected from one year to the next, even when weather promotes cedar health.

Yellow-cedar forests along the coast of Glacier Bay and in Prince William Sound remain healthy. However, a 100-acre patch of yellow-cedar mortality with old snags was reported in 2016 alongside La Perouse Glacier (Glacier Bay National Park), tens of miles northwest of the northernmost mapped decline. Ben Gaglioti of the Lamont Doherty Earth Observatory confirmed that the dead trees/snags are yellow-cedar, and that adjacent healthy forest also contains yellow-cedar. The snags in this patch appear to have died around 1990 based on secondary branch retention (time-since-tree-death can be estimated based on snag charactaristics). In May 2018, Gaglioti and his team sampled 100 cedar snags from (a) the 100-acre mortality patch on the moraine and (b) adjacent glacier-buried forest that has been uncovered by glacial recession (their main project objective). They will cross-date the samples to pinpoint when they died and to understand their population structure. This yellow-cedar mortality,

north of previously mapped decline, is of great interest, since cedar populations in Glacier Bay are considered healthy but at future risk of decline.

We continue to monitor young-growth stands for symptoms of yellow-cedar decline. Prior to 2012, young-growth stands were thought to be protected from freezing injury by relatively deeper rooting on productive sites, but 33 young-growth stands with decline symptoms have now been detected. In 2018, we installed 41 plots in five young-growth stands with the most severe decline crown symptoms and mortality to quantify impacts. Read more about decline in young-growth here and read the report from this plot installation effort here.

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Yellow-Cedar Decline Summary

Yellow-cedar decline is linked to climate change. Yellow-cedar trees are killed by freezing injury to fine roots where there is insufficient snowpack to insulate roots from lethal cold temperatures (<-5°C, 23°F) during cold events in early-spring. Root and foliar tissue of yellow-cedar prematurely dehardens in spring, which makes it vulnerable to severe cold at this time.

As a long-lived tree, many affected yellow-cedar forests established under the colder, more favorable climate of the Little Ice Age (1400-1850). An abnormal rate of yellow-cedar mortality began in the late 1800s, spiked in the 1970s and 1980s, and continues today.

Yellow-cedar is relatively more abundant on sites with high water tables, where it faces less competition from western hemlock and Sitka spruce. Although yellow-cedar is more competitive on wet sites, shallow rooting translates to greater vulnerability to fine root-freezing injury. Research into root and foliar cold tolerance has shown that yellow-cedar roots are more sensitive to this type of injury than associated conifers.

From the time crown symptoms appear, it often takes 10 to 15 years for trees to die, making it difficult to associate observations from aerial surveys to weather events in particular years. Impacted forests tend to have mixtures of old dead, recently dead, dying, and living trees, indicating the progressive nature of tree death.

Yellow-cedar is extraordinarily decay resistant and trees often remain standing for 80 to 100 years after death, allowing for the long-term reconstruction of yellow-cedar population dynamics in unmanaged forests. Long-term retention of wood properties provides opportunities for salvage harvest to offset harvest from healthy forests.

Even in severely affected forests, it is typical for 20-30% of the yellow-cedar basal area to remain alive; residual healthy trees are thought to be protected by microsite factors (deeper rooting) or tree genetics (freezing tolerance). On a regional scale, excessive yellow-cedar mortality may lead to diminished populations (but not extinction), especially considering this species' low rate of regeneration and recruitment in some areas. These losses may be balanced by yellow-cedar thriving in other areas, such as higher elevations and un-impacted parts of its range to the northwest.

Land managers can promote yellow-cedar through thinning to reduce competing vegetation or planting it on sites where it is expected to thrive into the future (deep soils and persistent snowpack). Yellow-cedar is preferred deer browse, and deer may significantly reduce regeneration in locations where spring snowpack is insufficient to protect seedlings from early-season browse.

Forest with yellow-cedar decline near Peril Strait, Chichagof Island.

A planted yellow-cedar on Prince of Wales Island.

A naturally-regenerated yellow-cedar seedling.

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Historic Activity

Our information on tree ages indicates that most of the trees that have died within the last century, and continue to die, regenerated during the Little Ice Age (~1400 to 1850 AD). Heavy snow accumulation is thought to have occurred during this period, giving yellow-cedar a competitive advantage on low-elevation sites in Southeast Alaska. Trees on these low-elevation sites are now susceptible to exposure-freezing injury under warmer climate conditions. An abnormal rate of yellow-cedar mortality began around 1880, accelerated in the 1970s and 1980s, and continues today. These dates roughly coincide with the end of the Little Ice Age and a warm period in the Pacific Decadal Oscillation, respectively. On a finer temporal scale, recent analysis of 20th century weather station data from Southeast Alaska documented increased temperatures and reduced snowpack in late winter months, in combination with the persistence of freezing weather events in spring (Beier et al. 2008). From the time crown symptoms appear, it takes 10 to 15 years for trees to die, making it difficult to associate observations from aerial surveys to weather events in particular years. Although there is continued activity of yellow-cedar decline, mortality has subsided somewhat in the last two decades.

Recent mortality is most dramatic on the outer and southern coast of Chichagof Island (Peril Strait) and at higher elevations, indicating an apparent northward and upward spread that is consistent with the climate patterns believed to trigger mortality. At the southern extent of decline in Alaska (55-56° N), mortality occurs at relatively higher

elevations, while farther north, decline is restricted to relatively lower elevations. Yellow-cedar forests along the coast of Glacier Bay and in Prince William Sound appear healthy, presumably protected by deeper and more persistent snowpack. In 2004, a collaborative aerial survey with the British Columbia Forest Service found that yellow-cedar decline extended at least 100 miles south into British Columbia. Since that time, continued aerial mapping around Prince Rupert and areas farther south have confirmed more than 120,000 acres of yellow-cedar decline in BC.

More than a half-million acres of decline have been mapped in Southeast Alaska through aerial detection survey since surveys began in the late-1980s (see **table** of cumulative decline acreage by land ownership in Southeast Alaska), with extensive mortality occurring in a wide band from the Ketchikan area to western Chichagof and Baranof Islands. The cumulative estimate includes forests mapped in the 1980s that were killed since the turn of the century. This augments what is traditionally mapped during aerial detection surveys: actively dying trees with yellow-red tree crowns.

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Unraveling the Complex Causes of Yellow-Cedar Decline

Yellow-cedar decline functions as a classic forest decline and has become a leading example of the impact of climate change on a forest ecosystem. The term **forest decline** refers to situations in which a complex of interacting abiotic and biotic factors leads to widespread tree death, usually affecting one tree species or genus over an extended period of time. It can be difficult to determine the mechanism of decline, and the causes of many forest declines worldwide remain unresolved.

Our current understanding is that yellow-cedar decline is associated with freezing injury to fine roots that occurs where snowpack in early spring is insufficient to protect roots from late-season cold events. Yellow-cedar trees appear to be protected from spring freezing injury where snow is present, insulating tree roots and preventing premature root tissue dehardening (tissue activation following winter dormancy).

Hennon et al. (2012) provides a detailed summary of the interdisciplinary research approach at multiple spatial and temporal scales, along with extensive evaluation of the role of biotic agents (insects and pathogens) (Hennon 1986, 1990a), that unraveled the complex causes of yellow-cedar decline. Temporal patterns include the timing of yellow-cedar forest development and favorable climate (based on tree age), long-term linkages between climate patterns and pulses of decline, and fine-scale study of air and surface soil temperatures in research plots to identify temperature thresholds and mortality events. Spatial patterns range from landscape level (latitude and elevation, patterns of snow persistence), to site level (mortality concentrated where hydrology or bedrock restricts rooting depth and snowpack does not persist in early-spring), to tissue level (sensitivity of yellow-cedar to freezing injury in spring).

The hypothesis that has emerged is consistent with the observed patterns: conditions on sites with exposed growing conditions and inadequate snowpack in spring are conducive to premature root tissue dehardening, resulting in spring freezing injury to fine roots and gradual tree mortality. The temporal patterns help to explain why yellow-cedar occurs on many sites where it is currently maladapted.

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Symptoms & Damage

Symptoms of yellow-cedar decline include yellow-red-brown foliage discoloration (affecting greater than 15% of the tree crown) and crown dieback, which results from damage to the fine roots. Root-freezing injury often kills individual trees slowly over more than a decade, causing the tree crown to gradually thin and discolor. Some trees remain alive for decades with only 5-10% of the original foliated tree crown, having lost most of the biological and ecological function of a live tree. Affected forests often contain trees at various stages of decline.

Trees weakened by freezing injury may die rapidly if they are attacked and girdled by secondary bark beetles. Comprehensive assessment of pathogens and insects associated with declining trees found that Phloeosinus bark beetles (*Phloeosinus cupressi*) and Armillaria root disease play only minor roles in yellow-cedar mortality, attacking trees stressed by other factors (Hennon 1986, 1990a). However, the presence of these agents can indicate that trees have been stressed by root injury. Although it is not possible to see dead fine roots with the naked eye, it is possible to see dark-colored necrotic (dead) tissue moving up from dead coarse roots when the bark around the roots and root collar is removed.

Research on seasonal cold tolerance of yellow-cedar has demonstrated that yellow-cedar trees are cold-hardy in fall and mid-winter, but are highly susceptible to spring freezing. Yellow-cedar roots are more vulnerable to freezing injury, root more shallowly, and de-harden earlier in the spring than other conifer species in Southeast Alaska (Schaberg et al. 2005).

Click on image for larger version.

A dark-colored lesion at the root collar of a declining yellow-cedar crop tree with bark removed.

Mycelium of the Armillaria root rot fungus beneath the bark of a declining yellow-cedar.

Phloeosinus beetle galleries and larvae beneath the bark of a declining yellow-cedar crop tree.

Phloeosinus beetles beneath the bark of a declining yellow-cedar tree.

Phloeosinus beetles beneath the bark of a declining yellow-cedar tree.

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Ecological Impacts

Yellow-cedar is an economically and culturally important tree. The primary ecological effects of yellow-cedar decline are changes in stand structure and composition (Oakes et al. 2014). Snags are created, and succession favors other conifer species, such as western hemlock, mountain hemlock and western redcedar. In some stands, where cedar decline has been ongoing for up to a century, a large increase in understory shrub biomass is evident. Nutrient cycling may be altered, especially with large releases of calcium as yellow-cedar trees die. The creation of numerous yellow-cedar snags is probably not particularly beneficial to cavity-nesting animals because its wood resists decay, but may provide branch-nesting and perching habitat. On a regional scale, excessive yellow-cedar mortality may lead to diminished populations (but not extinction), especially considering this species' low rate of regeneration and recruitment in some areas. These losses may be balanced by yellow-cedar thriving in other areas, such as higher elevations and parts of its range to the northwest. Yellow-cedar is preferred deer browse, and deer may significantly reduce regeneration in locations where spring snowpack is insufficient to protect seedlings from early-season browse.

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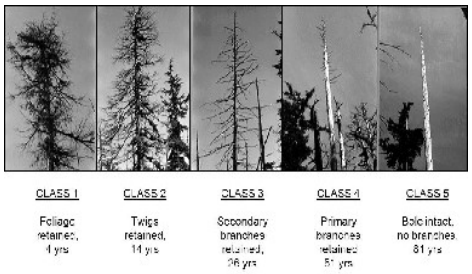
Salvage Logging

Salvage recovery of standing dead yellow-cedar trees in declining forests can help produce valuable wood products and offset harvests in healthy yellow-cedar forests. Cooperative studies between the Wrangell Ranger District, the USDA FS Forest Products Laboratory in Wisconsin, Oregon State University, the PNW Research Station, and Forest Health Protection have investigated the mill-recovery and wood properties of yellow-cedar snags that have been dead for varying lengths of time (Kelsey et al. 2005). Prior to this work, Hennon et al. (1990b) developed a snag classification system that relates snag characteristics to time since tree death. The mill recovery work has shown that all wood properties are maintained for the first 30 years after death. At that point, bark is sloughed off, the outer rind of sapwood (~0.6" thick) is decayed, and heartwood chemistry begins to change. Decay resistance is altered somewhat due to these chemistry changes, and mill-recovery and wood grades are reduced modestly over the next 50 years. Remarkably, wood strength properties of snags are the same as that of live trees, even after 80 years. Localized wood decay at the root collar finally causes sufficient deterioration that standing snags fall about 80 to 100 years after tree death. The large acreage of dead yellow-cedar, the high value of its wood, and its long-term retention of wood properties suggest promising opportunities for salvage. Read about a current project on the economic feasibility of salvage logging **here**.

Click on image for larger version.



Appearance, characteristics, and mean time-since-death for the five dead tree (snag) classes of yellow-cedar (Hennon et al. 1990b).

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Young-Growth Yellow-Cedar Decline

Yellow-cedar decline was recently observed for the first time in young-growth. Before this, it was thought that the fine roots of cedars in young-growth forests were protected from decline freezing injury by greater rooting depth on more productive sites managed for timber. In 2013, we investigated dying yellow-cedars in two adjacent young-growth stands on Zarembo Island and determined that the cause of tree damage was yellow-cedar decline. The affected stands had been thinned to favor abundant yellow-cedar.

Forest Health Protection has worked with the Tongass National Forest Silviculture Program to compile a database of young-growth timber units known to contain yellow-cedar, currently 338 stands, to facilitate monitoring (see **Map**). Low-altitude aerial imagery and aerial detection surveys are used alongside the database to identify stands with discolored tree crowns and suspected decline, which are subsequently inspected on the ground. Decline has now been ground-verified in 33 young-growth stands on Zarembo, Kupreanof, Wrangell, Mitkof and Prince of Wales Islands. Most affected stands currently have a low incidence of yellow-cedar mortality (1-15 trees), but three stands on Zarembo Island, one stand on Wrangell Island and one stand on Kupreanof Island are heavily impacted. In severe cases, up to half of the yellow-cedar crop trees are estimated to be dead or dying. Affected stands are typically 27 to 45 years old and thinned between 2004 and 2012; decline has now been detected in 18% of stands in this age bracket. Of the stands in our database, one-half are in this vulnerable age range and one-third are younger.

Current management recommendations are to maintain tight spacing between cedars (6-8 ft) during pre-commercial thinning to account for potential loss to crop trees, and to avoid thinning in wet portions of stands; thinning provides little tree-growth payoff on these sites and may contribute to greater soil temperature fluctuation. Key management treatments include promoting yellow-cedar through planting and thinning in areas suitable for the long-term survival of this valuable species. Understanding the risk factors for yellow-cedar decline in young-growth is a major research need. Predicting where decline is likely to occur in young-growth could allow managers to prioritize other conifers during thinning in some units or portions of units expected to be vulnerable to decline.

Bioevaluation reports are available from work on young-growth yellow-cedar decline on **Zarembo Island** (Mulvey et al. 2013, updated 2015) and **Kupreanof Island** (Mulvey et al. 2015) and from our effort to **quantify decline impacts in the most severely affected young-growth stands** on Kupreanof, Wrangell and Zarembo Islands (Mulvey et al. 2019).

Click on image for larger version.

A young-growth stand on Kupreanof Island with yellow-cedar decline, as seen by float plane.

Recently-killed crop tree on Zarembo Island that appears to have died rapidly due to its full red-brown crown.

Forest pathologists examine a declining yellow-cedar crop tree with a thin crown on Kupreanof Island.

A yellow-cedar crop tree on Zarembo Island with a thinning, discolored crown.

A healthy yellow-cedar crop tree on Zarembo Island above the main area of yellow-cedar decline in this stand.

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Recent Work & Current Events

Yellow-Cedar Petitioned for Endangered Species Act Listing: On October 7th, 2019, federal protection for yellow-cedar under the Endangered Species Act (ESA) was deemed unwarranted. The U.S. Fish and Wildlife Service's listing decision is available in the **Federal Register** (Vol. 84, No. 194). The petition to list yellow-cedar as endangered or threatened under the ESA was received on June 24th, 2014. The initial finding was that a review of the science and status of yellow-cedar was warranted. As part of the scientific review of yellow-cedar, the Yellow-Cedar Biology, Ecology, and Emerging Knowledge Summit was held at the University of Alaska Southeast in October 2017. The meeting was attended by experts from many disciplines from the United States and Canada and covered the best available science and information needs regarding yellow-cedar. The Yellow-Cedar **Species Status Assessment** was completed in December 2018.

> *We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the yellow-cedar, and we evaluated all relevant factors under the five listing factors, including any regulatory mechanisms and conservation measures addressing these stressors. The primary stressors affecting the species' biological status include the effects of climate change (including changes in temperature and precipitation patterns), timber harvest, fire, and herbivory. We found that yellow-cedar is experiencing a decline primarily caused by a changing climate in the core of its range; therefore, it has somewhat reduced resiliency. However, the area affected represents less than 6 percent of the species' range, and there are still high levels of representation and redundancy as demonstrated by its high levels of genetic diversity and wide distribution on the landscape, respectively. Despite impacts from effects of climate change, timber harvest, fire, and other stressors, the species is expected to persist in thousands of stands across its range, in a variety of ecological niches, with no predicted decrease in overall genetic diversity into the foreseeable future.* - USFWS Listing Decision, Federal Register Vol. 84, No. 194

Permanent Monitoring along the Northern Margin of Decline (2011-2015): Lauren Oakes completed her PhD at Stanford University in 2015 researching yellow-cedar decline in Southeast Alaska. She installed permanent monitoring plots along the outer coast of Chichagof Island, the northern margin of yellow-cedar decline, and in healthy yellow-cedar forests in Glacier Bay, to quantify changes in forest community structure in decline-affected yellow-cedar forests (Oakes et al. 2014). Key findings were that succession favors other conifer species, especially western hemlock, and that understory functional plant diversity and composition changed. She evaluated the current and expected future status of yellow-cedar in Alaska under climate change, and the cultural and social perspectives around active management of yellow-cedar on lands with varying protection status (Oakes et al. 2015a). Lauren explored the relationship between knowledge of, and adaptation to, widespread, climate-induced tree mortality (Oakes et al. 2015b). She has written a non-fiction book based on her graduate work, *In Search of the Canary Tree: A Story of a Scientist, a Cypress and a Changing World*, see her **website** for more details.

Natural Yellow-Cedar Migration in Alaska (2014-2016): University of Alaska Southeast/Fairbanks and the Forest Service undertook a project to understand the establishment, migration and spread of yellow-cedar populations near Juneau. John Krapek mapped all known yellow-cedar populations and established plots at their edges to examine regeneration success and stand expansion. Despite large areas of suitable habitat, yellow-cedar only occupies < 1% of its potential niche near Juneau, indicating an ongoing migration. Recent stand expansion appears limited, with the last major pulse of establishment during the Little Ice Age (1100–1850). Yellow-cedar migration in the region appears episodic, and tied to climate and/or forest conditions different than today (Krapek and Buma 2017).

Yellow-Cedar Salvage Potential (ongoing since 2014)**:** The **Alaska Coastal Rainforest Center**, Forest Service, State of Alaska, and University of Alaska Southeast are conducting a project to evaluate the economic feasibility of salvaging dead yellow-cedar. Monitoring plots have been installed on Kupreanof and Prince of Wales islands to compare forest composition, structure, seedling regeneration, and damage to residual trees from logging equipment in salvaged and unsalvaged stands impacted by yellow-cedar decline. Logging and milling costs will be tracked to assess the economics of this harvest against the value of the final products. Salvage recovery of standing dead yellow-cedar trees in declining forests may provide new opportunities for small mill operators, and can offset harvests in healthy yellow-cedar forests.

Rangewide Vulnerability Assessment (ongoing since 2015): Specialists from the US and Canada initiated a project in 2015 to evaluate the climate vulnerability for yellow-cedar throughout its entire range, from northern California to Prince William Sound in Alaska (Buma et al. 2016). Future work will incorporate climate models related to freezing injury, drought, and fire disturbance events.

Common Garden Studies (ongoing since 2009/10): A yellow-cedar common garden study has been established at the Héen Latinee Experimental Forest near Juneau and at several sites on Prince of Wales Island to evaluate differences in growth and survival between seedlings of different genetic sources and collection locations. Heavy deer

browsing pressure on Prince of Wales caused notable mortality of seedlings. Seedlings near Juneau have experienced very high survival and growth, presumably because snow protected them from early-spring browse at this site. In 2009, 3,300 one-year-old plugs of yellow-cedar were planted across 30 total acres at three sites in Yakutat. Seedling survival was very high (90%) in post-planting measurements, but within the last two years survival has dropped to an estimated 20-30%. Planting sites were visited by Tongass silviculturists and Forest Health Protection staff in August 2017. Restricted rooting depth and seasonal flooding at planting sites in the Yakutat forelands likely increased vulnerability to fine root freezing injury in the absence of insulating snowpack. Survival was noticeably higher along skid roads, where equipment had churned the soil. The use of plugs may have also resulted in compromised root structure. A canker disease was also detected on some seedlings and collected for diagnosis. The causal fungus was cultured and genetically sequenced and is thought to belong to the genus *Allantophomopsis,* but an exact species-level sequence match was not found.

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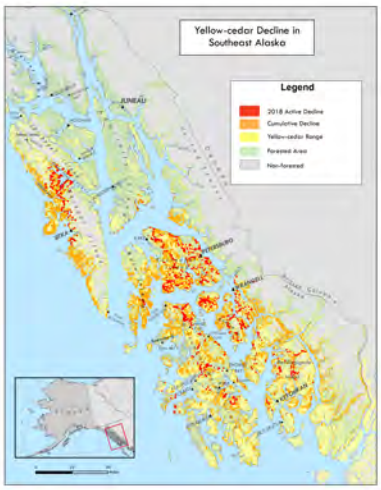
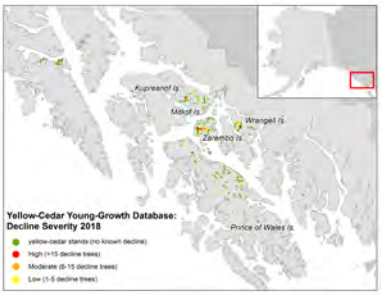
Maps

Click on image for larger version.



Active and cumulative yellow-cedar decline mapped by aerial detection survey in Southeast Alaska as of 2018 with the distribution of yellow-cedar.



Young-growth stands that contain yellow-cedar and the severity of yellow-cedar decline in 33 affected stands (2018).

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Resources & Publications

Click here *to access more than 50 yellow-cedar publications. Also see the annotated bibliography of yellow-cedar (Hennon and Harris 1997), and Literature Cited sections of Hennon et al. (2016, 2012).*

Hennon, P. E ; Harris, A. S. 1997. Annotated bibliography of *Chamaecyparis nootkatensis*. Gen. Tech. Rep. PNW-GTR-413. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 119 p. Available **here**.

Hennon, P. E.; D'Amore, D. V.; Schaberg, P. G.; Wittwer, D. T.; Shanley, C. S. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow-cedar in the North Pacific coastal rainforest. BioScience. 62: 147-158. Available **here**.

Hennon, P. E.; McKenzie, C. M.; D'Amore, D. V.; Wittwer, D. T.; Mulvey, R. L.; Lamb, M. S.; Biles, F. E.; Cronn, R. C. 2016. A climate adaptation strategy for conservation and management of yellow-cedar in Alaska. Gen. Tech. Rep. PNW-GTR-917. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 382 p. Available **here**.

Content prepared by Robin Mulvey, Forest Pathologist, Forest Health Protection, robin.mulvey@usda.gov.

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Geomorphology 117 (2010) 155–169

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/geomorph

The incidence and role of gullies after logging in a coastal redwood forest

Leslie M. Reid *, Nicholas J. Dewey, Thomas E. Lisle, Susan Hilton

US Forest Service Pacific Southwest Research Station, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521, USA

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ABSTRACT

The distribution and morphological characteristics of channels were mapped in a redwood forest at Caspar Creek, California, USA, to evaluate the extent to which recent logging has influenced channel conditions in the area. In the North Fork Caspar Creek watershed, second-cycle logging of the early 1990s appears to have triggered increased coalescence of discontinuous gullies within clearcut tributary watersheds, and upstream channel limits in logged watersheds are now located significantly farther upslope than in control watersheds. The magnitudes of observed increases in peakflow after logging are consistent with the change in drainage density. Relations between channel morphological variables and indices of stream power are less well-defined in logged watersheds than in controls, suggesting that logging may have led to disruption of previously established channel forms. Correlations between suspended sediment yields and indices of gully erosion suggest that in-channel erosion associated with hydrologic change is an important source of post-logging sediment at Caspar Creek. Common sediment-control measures, such as use of riparian buffer strips and reduction of road surface erosion, would not be effective for reducing sediment input from this source.

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1. Introduction

Gullying has been triggered by increased runoff and reduced vegetation cover in many areas and is of great concern to land managers (Valentin et al., 2005). Gullies contribute to loss of fertile soils, disrupt transportation networks, and depress water tables in floodplains; and they create persistent sources of sediments that reduce water quality, fill reservoirs, aggrade downstream channels, and impair aquatic habitats. Gullying can increase sediment yields both through incision of existing channels and by expansion of drainage networks into previously unchanneled swales. In the latter case, channel incision may increase transport capacity through the swale, providing hillslope-derived sediment more direct access to downstream channels (Reid, 1989).

Most studies of gullies have been carried out in agricultural lands, grasslands, or arid areas, where the features are most visible and where they most directly challenge land-management activities; gullies in forests are less commonly encountered. Gullying occurred in some areas after conversion of forest to pasture or agriculture (e.g., Gábris et al., 2003; Parkner et al., 2006). In several areas, however, gullies have been identified as major sediment sources within unconverted forest lands. Often forest gullies are associated with road drainage or with areas compacted by logging equipment (e.g., Weaver et al., 1995; Croke and Mockler, 2001), but in other cases gullying appears to be a more generalized response to forest management (Heede, 1991) or to temporary vegetation changes upslope of the forested area (Vanwalleghem et al., 2003) or is an inherent feature of the forested setting (Parkner et al., 2007).

In part because of the long duration of forest management cycles and the inability to detect forest gullies on historical aerial photographs, the incidence of forest gullies and their relation to forest management remain poorly understood, particularly in settings where overland flow is uncommon. Observed changes in gully activity with forest conversion and subsequent reforestation (e.g., Gábris et al., 2003; Parkner et al., 2006) indicate that catchment vegetation can influence gullying and that those influences vary by vegetation type. Forest vegetation commonly has larger roots and produces larger quantities of coarse litter than other vegetation types, and forests provide woody debris that retains sediment on hillsides and in small channels (Maser et al., 1988). Vegetation type is also expected to influence runoff volumes (Bosch and Hewlett, 1982), peakflow magnitudes (Guillemette et al., 2005), and snowmelt timing (Winkler et al., 2005), each of which could influence gully erosion rates during short-term perturbations in vegetation cover. Vegetation can also regulate gully activity at a smaller scale. For example, Molina et al. (2009) have shown that herbaceous and shrubby vegetation on gully floors is effective in trapping sediment.

During recent forestry planning efforts in NW California, unanswered questions were raised concerning the role of management-related channel erosion in sediment production. This paper presents the results of a study implemented in the Caspar Creek Experimental Watersheds of north coastal California, USA, to (i) evaluate the distribution of incised channels and associated headcuts in the area; (ii) assess the relative importance of gully erosion as a sediment

* Corresponding author. Tel.: +1 707 825 2933; fax: +1 707 825 2901.
E-mail addresses: lreid@fs.fed.us (L.M. Reid), ndewey@jeffco.k12.co.us (N.J. Dewey), tlisle@fs.fed.us (T.E. Lisle), shilton@fs.fed.us (S. Hilton).

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source there; and (iii) identify potential influences of forest land management on the extent and character of the gullied reaches.

2. Study area

The Caspar Creek Experimental Watersheds (N39°21′ W123°44′) include the 424-ha South Fork and 473-ha North Fork tributaries of Caspar Creek, which drains to the Pacific Ocean 10 km south of Fort Bragg, CA (Fig. 1). The Caspar Creek catchment is deeply incised into a flight of uplifted marine terraces formed over more than 300,000 years on Franciscan sandstone and shale (Merritts et al., 1991). Elevation in the experimental watersheds ranges from 37 to 320 m, with hillslopes steepest near the stream channel and becoming gentler near the broad, rounded ridgetops. About 35% of the slopes are lower than 17° and 7% are steeper than 35°. Longitudinal channel profiles are generally concave, but many include low-gradient reaches (1° to 5°) immediately followed by relatively short steeper reaches (5° to 20°). Mainstem channels and many tributary segments are bordered by narrow valley flats. Radiocarbon dating of charcoal in 3- to 4-m-deep valley fills in upper reaches of the North Fork suggests that deposition began about 7000 ^{14}C YBP and proceeded episodically through the middle to late Holocene (Steven Reneau, Los Alamos National Laboratory, personal communication, 1989).

The climate is typical of coastal watersheds in the region: winters are mild and wet, while summers are mild and dry. About 95% of the average annual precipitation of about 1200 mm occurs in October through April, and most rain falls in storms of long duration but low intensity. Snow is uncommon.

Soils are predominantly gravelly to sandy loams with a typical depth of 1.5 m. The upper meter of the most common soils includes 25 to 50% gravel and cobble and 30 to 50% clay and silt, and has a bulk density of 1.4 to 1.6 Mg m^{-3} (Wosika, 1981). Subsurface stormflow is rapid, and saturated areas are uncommon and drain quickly after storms. Soil pipes are present in most swales and transport a substantial discharge of storm flow to low-order channels (Albright, 1991). Channel flow often becomes spatially intermittent within a few weeks of a winter storm in catchments smaller than 20 ha (L. Keppeler, USFS, personal communication, 2008).

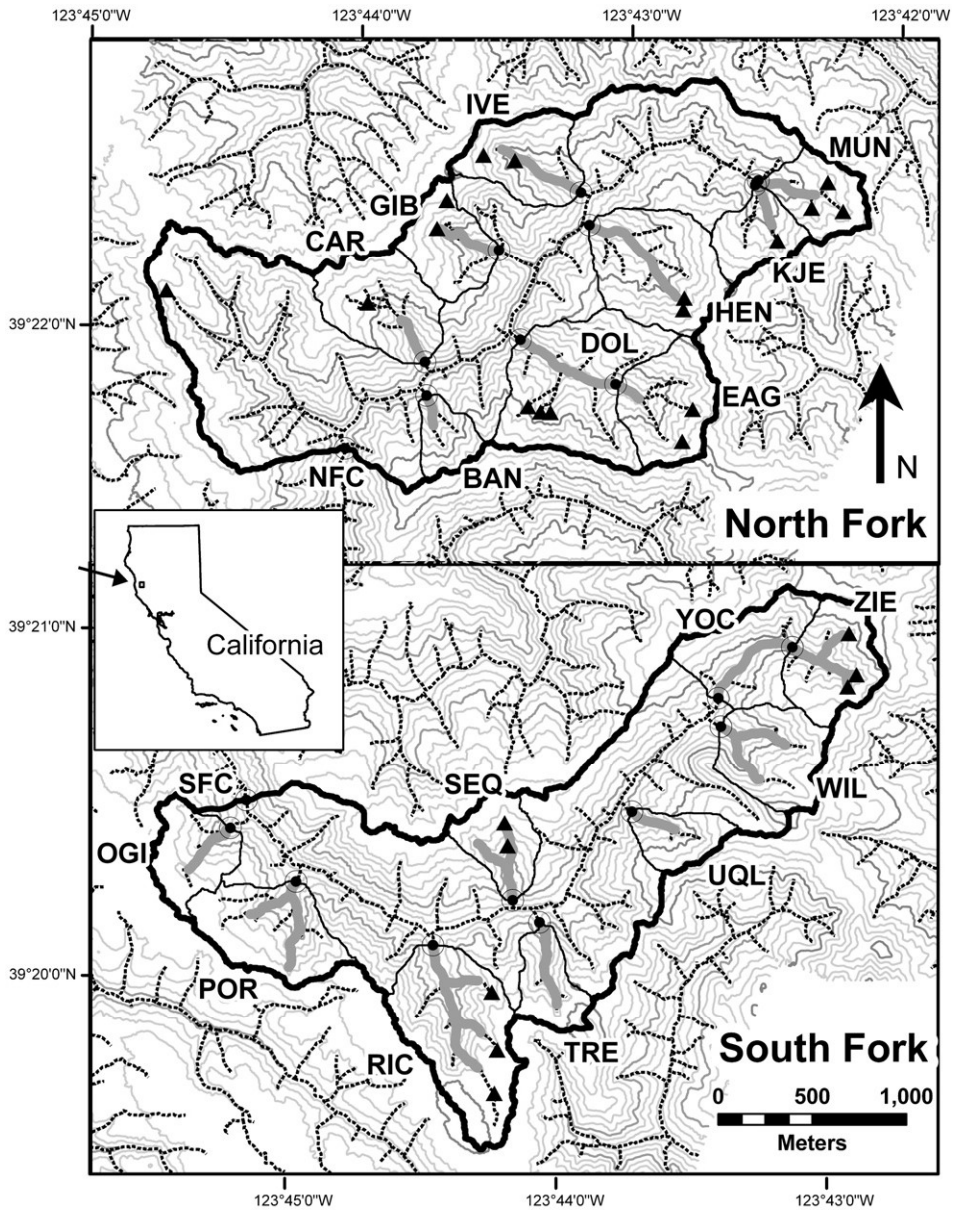

Fig. 1. The Caspar Creek experimental watersheds. Tributaries in which headcuts were mapped are shown in gray, dots indicate location of gaging stations, and triangles indicate locations of mapped channel limits.

Both experimental watersheds are densely forested with second- or third-growth stands dominated by coastal redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*). The entire study area was first logged between 1860 and 1904 using cleared-out channels as routes for log transport (Napolitano, 1998). The low incidence of old-growth wood in today's channels reflects this use, presenting a contrast to the high volumes of very large woody debris present in channels draining old-growth redwood forests of the region (e.g., Keller et al., 1995).

The Caspar Creek Experimental Watersheds were established in 1961 as a long-term research site run jointly by the California Division of Forestry and Fire Protection and the U.S. Forest Service (USFS) Pacific Southwest Research Station. Weirs and gaging stations were constructed by November 1962 on the North and South Forks. After an initial period of calibration between the two watersheds, roads were constructed in the South Fork in 1967, and nearly two-thirds of the stand volume was selectively logged from 1971 to 1973. Tractors commonly dragged logs down tributary valleys, once again severely disturbing some channels.

Twelve years after South Fork logging, thirteen additional gaging stations were constructed in tributaries and along the main stem of the North Fork. The new stations underwent calibration for 4 years. Thirty-seven percent of the North Fork watershed was then roaded, clearcut, and cable-yarded from ridgetops between 1989 and 1992. Selectively logged buffer strips were left around channels with drainage areas of greater than about 10 to 12 ha, and three subcatchments (HEN, IVE, and MUN, Fig. 1) were left as mature second-growth controls within the North Fork watershed. All watersheds but BAN and HEN included some roads constructed long before calibration began, and both new and old roads were located near ridges.

Both episodes of experimental logging resulted in increased runoff and sediment yield, followed by substantial recovery within a decade of logging (Ziemer, 1998). In the North Fork watersheds, increases in sediment production were correlated with increases in storm runoff (Lewis et al., 2001), which were attributable largely to reduced rainfall interception and transpiration after logging (Reid and Lewis, 2007). Ten new gaging stations were constructed on South Fork tributaries in 2000 in preparation for a third experiment.

Stands representing three broad categories are now present in the North and South Fork watersheds. In North Fork control watersheds, the overstory is dominated by 100- to 140-year-old redwoods and Douglas-firs with diameters at breast height (DBH) of about 70 to 150 cm. A subcanopy composed of hardwoods (principally tanoak, *Lithocarpus densiflora*) and small conifers is present at most sites, and shrubs, ferns and herbs provide a discontinuous ground cover. Total stand density for stems larger than 12.7 cm DBH is typically on the order of 500 stems/ha, with a basal area of about 100 $m^2\ ha^{-1}$ as of 1998. South Fork stands reflect the selection logging of the early 1970s, having a higher density of small trees than North Fork stands but including a similar range of stem sizes. South Fork stands typically have 600 to 1200 stems/ha and basal areas of 65 to 85 $m^2\ ha^{-1}$ as of 2009. The North Fork watersheds logged in 1989–1992 were clearcut, leaving only a disturbed and discontinuous cover of shrubs and herbs. Regrowth has been rapid, and herbicides were applied to watersheds EAG and GIB in 1994 and again in 1996 to control growth of shrubs and hardwoods, while logged watersheds BAN, CAR, and KJE were not treated. Logged watersheds were then thinned in 1998 (KJE) or 2001, leaving about 800 to 2000 stems/ha (basal area: 3 to 5 $m^2\ ha^{-1}$) and reducing crown area to about 20% of that present before thinning.

Most tributary segments with catchments larger than 1.9 ha show evidence of active incision characteristic of gullying, such as steep, raw banks, eroding headcuts, quasirectangular cross sections, and low width–depth ratios (Fig. 2). Old-growth roots often span channels or form headcut lips, and many old-growth stumps are now being undermined by gully-bank erosion and are toppling into channels.

Fig. 2. Headcut in MUN tributary, North Fork Caspar Creek. Note knapsack for scale; headcut is 1 m high.

Much of the valley-axis area thus had supported trees for centuries, and gullies have expanded significantly since the trees were cut during first-cycle logging. Either previous gullies were limited in extent or earlier episodes of extensive gullying had stabilized by about 400 years ago. Many gullies in both confined reaches and valley flats excavate saprolite, also suggesting that the current extent of gullying is unprecedented.

At gully headcuts, the stream typically flows over a lip reinforced by a large root or piece of woody debris and scours a plungepool below. Several modes of headcut erosion are observed in the area: (i) gradual backwasting of the exposed face through ravel, spalling, and tractive erosion, (ii) sapping or tunnel erosion, with rapid retreat occurring when the upstream tunnel enlarges enough that a portion of the roof collapses, (iii) block failures induced by undercutting from backwasting, plungepool erosion, or sapping, and (iv) rapid tractive erosion when a reinforced lip loses its influence, causing a sudden drop in base level to the upstream reach. Most headcuts and associated plungepools show complex forms modified by woody debris, roots, bedrock, boulders, and in-place or toppled bank vegetation; few exhibit the regular morphology typical of grassland gullies. Little vegetation other than moss is present in growth position on gully floors.

3. Methods

The study relies on four kinds of data: (i) measurements of gully distribution and characteristics recorded during field surveys carried out during 2000–2002 and 2006–2008; (ii) measurements of process rates monitored within a subset of the gullies; (iii) sediment gaging records from gullied tributaries; and (iv) information from earlier studies of surface erosion and landslide distribution in the area.

3.1. Gully distribution and dimensions

Channel characteristics were mapped along the main axes of 16 tributaries from near the mouth of the channel to a point above which the drainageway is no longer primarily in the form of an active channel; this aspect of the study is described in more detail by Dewey (2007). Above most of the upstream mapping points in North Fork control channels and South Fork channels are 1 to 4 ha of swale in which either unchanneled reaches predominate or most of the channel is inactive and filled with duff. Additional pipe collapses and discontinuous gullies occur upstream of mapped reaches, and mapped reaches include occasional unincised zones. During this

phase of the study, the upstream end of the channel could not be readily found in some clearcut watersheds where channels were obscured by dense regrowth and logging debris. Hillslope gullies and subsidiary tributaries generally were not mapped, but both branches of the main tributary channel were mapped if the dominant fork could not be identified.

In North Fork tributaries, headcut locations and channel width and depth measurements were added to a preexisting channel map. In the South Fork, channels had not previously been mapped, so tributary thalwegs were mapped relative to tapelines established from surveyed benchmarks. Tapeline slope was calculated from surveyed endpoint locations or measured with a hand level; and a stadia rod was used to measure bank height, channel width, and thalweg elevation relative to the tapeline.

Bank-to-bank width and bank-to-thalweg depth were measured at 1074 locations along 3290 m of valley axis in eight North Fork tributaries and at 2124 locations along 5670 m in eight South Fork tributaries. Depth is reported as an average of measurements taken relative to the left and right banks, and depth and width are interpolated linearly between measurement points to allow estimation of average values for 25- and 50-m channel segments. In North Fork tributaries, the product of depth, width, and channel increment length is summed by 2-m channel pixels to estimate channel-segment volumes. South Fork volumes are estimated by summing values for measurement-bounded channel increments. Measurements from 18 surveyed cross sections indicate that the product of thalweg depth and bankfull width overestimates cross-sectional area in these tributaries by a factor of 1.40 (95% confidence interval: ± 0.09), with no significant dependence on width-to-depth ratio, and this value is used as a correction factor for estimating volumes.

Each mapped channel contains many vertical or near-vertical steps in its long profile. These features were classified as headcuts for this study if the step face included some component of material other than woody debris or bedrock. The location and height (relative to the plungepool nadir) of almost all headcuts higher than 0.3 m were recorded, but only headcuts higher than 0.44 m are considered in this analysis in order to ensure a consistent resolution between tributaries. The distribution of recorded heights suggests that 0.26- to 0.44-m headcuts would account for 15 to 20% of the headcuts higher than 0.26 m, or about 7 to 10% of the total headcut height, so exclusion of these features from the data set is not expected to substantially influence conclusions. A 2-m digital elevation model (DEM) was used to estimate drainage area and elevation at each channel pixel in the North Fork, while results from the South Fork are based on information from a 10-m DEM.

To evaluate the extent of the channel network, upstream channel limits were subsequently mapped in 10 forested tributaries and 7 clearcut tributaries in North Fork watersheds and in 8 South Fork catchments (Fig. 1). Because channels are discontinuous in their upstream reaches, the limit was defined for this portion of the study as the upper boundary of the upstream-most channel segment longer than 5 m that has well-defined banks and appears to have carried flow within the previous decade.

We evaluate the distribution of incised channels and associated headcuts by testing for patterns of association between headcut characteristics or channel form descriptors and such factors as drainage area, stream power, and treatment category. Because channel characteristics vary by position in the watershed and because different sections of each watershed were logged or mapped (Table 1), long-profile variations in channel and headcut characteristics must be accounted for if differences in characteristics between treatment groups (i.e., control, recently clearcut North Fork, and selectively logged South Fork watersheds) are to be validly identified. To do so, each channel or headcut characteristic identified for 25- or 50-m reaches within a treatment group was first regressed individually against catchment area, channel gradient, and a stream power index (the product of catchment area and segment gradient, as defined by Montgomery and Dietrich, 1989). If a significant relationship to one of these variables was found, multiple regression was used to determine if treatment is an additional significant variable, with significance assessed at the 0.05 level throughout the sequence of analyses. Comparisons are restricted to data from

Table 1
Mapped tributaries at Caspar Creek; channel attributes are reported here only for the mapped portion of the channel network.

	Gaged area (ha)	Percent logged	Percent roads[a] 1986	1995	Gage record	Area above survey (ha)	Total channel length (m)[b]	Buffer strip length (m)	Surveyed channel length (m)	Surveyed channel volume (m^3)	Surveyed bank area (m^2)	Headcuts >0.44 m
North Fork clearcut 1989–91												
BAN	10	95	0.0	3.5	1985–1995	5.1	875	88	157	63	106	19
CAR	26	96	4.7	6.4	1985–now	14.2	2343	242	284	611	646	15
DOL[c]	77	36	–	–	1985–now	26.6	–	n.a.	586	1243	1174	37
EAG	27	100	0.8	4.6	1985–now	8.9	2406	105	149	339	383	6
GIB	20	100	5.2	7.8	1985–1995	1.2	2115	107	360	312	427	41
KJE	15	97	0.3	6.3	1985–1995	3.7	1179	235	253	1511	880	14
North Fork control												
HEN	39	0	0.1	0.1	1985–now	3.7	3341	n.a.	675	640	821	78
IVE	21	0	7.6	7.6	1985–now	3.4	948	n.a.	494	512	625	53
MUN	16	0	5.2	5.2	1985–1995	6.9	1293	n.a.	330	633	467	21
South Fork selectively cut 1971–73												
OGI[d]	18	50	–	–	2000–now	5.2	–	n.a.	350	337	495	18
POR	32	54	–	–	2000–now	1.7	–	n.a.	780	1207	1135	41
RIC	49	67	–	–	2000–now	1.3	–	n.a.	1144	1356	1477	75
SEQ	17	67	–	–	2000–now	1.2	–	n.a.	668	845	810	45
TRE	14	67	–	–	2000–now	1.8	–	n.a.	489	464	665	33
UQL	13	67	–	–	2000–now	3.4	–	n.a.	269	258	316	42
WIL	26	67	–	–	2000–now	3.5	–	n.a.	699	687	867	94
YOC[c]	53	67	–	–	2000–now	25	–	n.a.	575	645	750	41
ZIE	25	67	–	–	2000–now	1.4	–	n.a.	694	458	706	57

[a] Percent of area in roads and landings; values are approximate due to potential instability of drainage patterns on ridge-top roads.
[b] Includes all sub-tributaries, as estimated from DEMs on the basis of expected headwater catchment area; value listed for DOL is exclusive of length in EAG.
[c] DOL is located downstream of EAG, and YOC is downstream of ZIE; surveyed values listed for DOL and YOC pertain only to the segment of the watershed below the upstream gage.
[d] OGI includes 27% private land that has been selectively logged several times since 1971.

watershed areas of 3 to 30 ha to ensure that samples are available from similar locations in both logged and control watersheds.

3.2. Gully erosion rates

Tributaries YOC, ZIE, and MUN (Fig. 1) were selected for monitoring of headcut changes over a multi-year period using one of three methods. Five headcuts (group I) were surveyed in detail with an electronic total station in the summers of 2000 and 2002. The resulting maps are capable of revealing local changes of more than about 5 cm. At six other headcuts (group II), transects were surveyed first by survey laser and later by rod and tape to measure headcut retreat and bank erosion upstream and downstream of the headcut; survey error is estimated to be about 2 cm. An additional 41 headcuts (group III) were visually checked for obvious retreat, with changes >30 cm expected to be visible. Headcuts were revisited during the summer of 2003 and in February 2004, and additional measurements were made at three rapidly eroding headcuts. Nine headcuts from groups I and II at which benchmarks could be relocated were again surveyed in 2006 and 2008 using an electronic total station. Cross-section measurements from groups I and II also allowed monitoring of bank erosion on 15 near-vertical banks between the summers of 2000 and 2002; 12 of the 15 measurements are from banks within 4 m downstream of a headcut. Flow conditions over the monitoring period ranged widely: the highest flow recorded at IVE during 24 years of monitoring occurred in December 2005, while all other years produced maximum flows with recurrence intervals of less than 2 years.

During the autumn of 2000, paint was applied to roots at the point at which each emerged from a headcut face to allow long-term monitoring of bank recession at several headcuts. Distances between the wall surface and the painted portions of roots were measured at 43 points on four headcut overfalls during July 2008.

In calculations of erosion rates, a bulk density of 1.5 Mg m^{-3} is assumed when converting rates from units of $m^3\ y^{-1}$ to Mg y^{-1}.

3.3. Suspended sediment transport at gaging stations

We use records from nine tributary gaging stations in the North Fork watershed (Fig. 1; Table 1) to evaluate variations in annual suspended sediment yield as they may relate to gullying; results of the suspended sediment study evaluated by storm period are reported elsewhere (Lewis, 1998; Lewis et al., 2001). Automatic sediment samplers at each gage are programmed to sample at predetermined turbidity levels. These sediment measurements allow ongoing recalibration of the turbidity record at each gage in order to produce a continuous estimate of suspended sediment concentration during storms (Lewis, 1996), and transport rates are then computed from discharge and concentration. Measured storms account for 90 to 99% of sediment output in most years (Jack Lewis, USFS, personal communication, 2007), with the highest percentages for years with large flows, so the approach is expected to account for at least 95% of the suspended load during the period analyzed.

For the current study, analysis requires annual loads rather than storm-period loads, so storm loads had to be estimated at several stations during periods with missing record. Loads at individual stations were estimated for missing portions of the pre-logging record using correlations between peakflow and storm sediment load or between loads at nearby gages if peakflow data were missing. Regressions are not expected to be stable during the post-logging period, so missing values after logging were estimated using ratios between the target storm load and temporally adjacent storm loads at stations with records for the missing storm. Imputed values account for about 4% of the total suspended sediment load.

3.4. Other erosion studies

The incidence of landslides and treethrows mobilizing more than 7.5 m^3 has been recorded in the North Fork watershed since 1986 through "large-event surveys" carried out during post-storm channel inspections. Each event is located on a channel map with reference to existing benchmarks, and the scar is diagramed and dimensions measured. Associations with roads or treethrows are noted if present, and the volume of displaced sediment still present on the scar is estimated.

Surficial erosion has also been evaluated in the area. Rice (1996) reported results of void measurements on erosion plots at 175 hillslope sites and 129 road sites distributed randomly through the North Fork watershed after completion of second-cycle logging. Sample units on logged and unlogged hillslopes were circular 0.08-ha plots, while those on roads were 1.5-m-wide segments of the road prism oriented perpendicular to the road centerline. Processes assessed on plots include rilling, sheet erosion, and soil displacement from yarding. Rice weighted erosion plot data according to the proportion of the sub-watershed logged and the road length present in each and reported results as average total erosion per unit area of each sub-watershed.

Rice's results require reevaluation for the current study because several sub-watersheds had experienced different durations since logging at the time of the survey (1995). Given the large reported differences in erosion between logged and unlogged sites (Rice, 1996), most soil displacement appears to be associated with treatment, so Rice's estimates for rates of road and hillslope surface erosion are here recalculated as erosion per year since the onset of construction of new logging roads in the treated watersheds. Rates for the control watersheds are also calculated assuming a 5-year period of visibility rather than the 10-year period implicitly assumed by Rice (1996).

For the calibration period, hillslope surface erosion is estimated simply as the mean of the rates calculated for the post-calibration period in the three control watersheds. This approach cannot be adopted to estimate road-related erosion during the calibration period because road erosion for the post-calibration period in both logged and control watersheds reflects the period of high-intensity use during logging. Results from Reid and Dunne (1984) suggest rates of surface erosion on gravel-surfaced logging roads are about 75 times higher during high-intensity use periods than during periods of light use. Log hauling typically took place over a 4-month period within each logged watershed, and mainline roads in all watersheds would have undergone longer periods of heavy use as neighboring units were logged. Road erosion rates are assumed to be 75 times higher than "background" road erosion rates for a 4-month period during the post-calibration period, and the corresponding rate for light-use periods is then calculated algebraically from the road erosion plot data (i.e., $plot\ \ total = (0.33\ year \times 75x) + [(post\text{-}calibration\ \ duration - 0.33\ year) \times x]$, where x = rate for the light-use period). The mean of estimated light-use rates calculated per unit area of road is then applied to the area of roads present during the calibration period in each watershed.

4. Results

4.1. Gully distribution and characteristics

Gully headcuts are common along all mapped valley axes (Fig. 3, Table 1), with some present in catchments of <1 ha. There are 284 mapped headcuts higher than 0.44 m in North Fork tributaries and 446 in South Fork tributaries, indicating average frequencies of 8.6 and 7.9 headcuts per 100 m of channel, respectively. Differences in gully characteristics between logged and control watersheds are not evident to casual observation (e.g., Fig. 3), indicating that any major

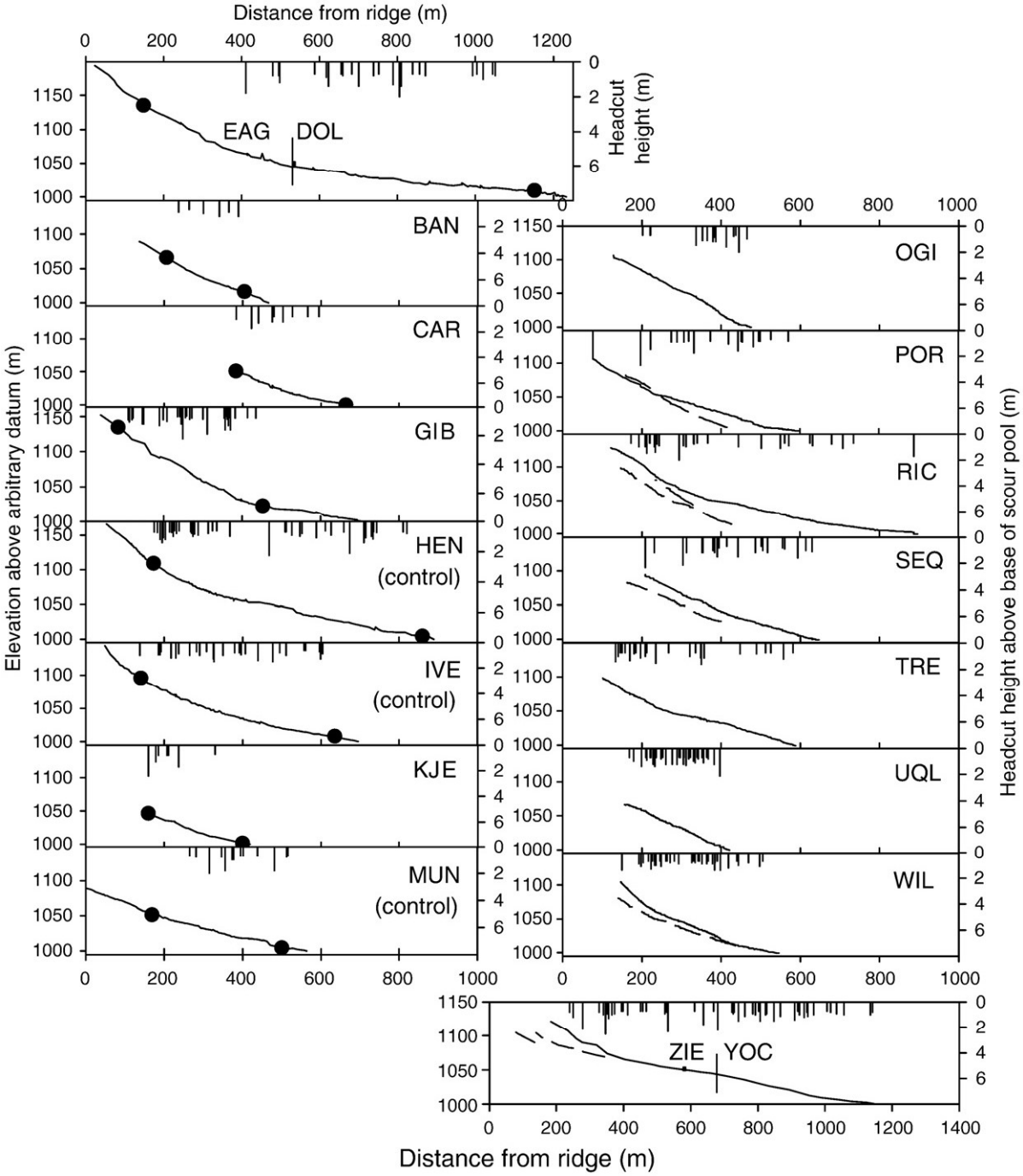

Fig. 3. Surveyed valley-axis profiles in gaged tributaries. Tics indicate the locations and heights of headcuts along the main tributary channel, and dashed lines show profiles of additional mapped branch tributaries. Dots on North Fork profiles indicate the limits of headcut mapping. For clarity, mapped headcuts shorter than 0.64 m are omitted. See Table 1 for watershed descriptions.

incision episode predated second-cycle logging. In particular, the logged KJE catchment was noted to have exhibited particularly well-developed gullies even before the recent logging.

Headcut characteristics are assessed for 50-m channel reaches; analysis of shorter reaches would provide too few headcuts in each sample unit. Headcut height (h) in North Fork tributaries increases weakly but significantly with channel-segment gradient (s) ($\log h = -0.34 + 0.58s$, $p < 0.001$, $r^2 = 0.064$), and the relation shows no significant difference between logged and control tributaries. In contrast, mean headcut spacing decreases significantly with increasing gradient (Fig. 4), and headcuts in control watersheds are spaced significantly more closely than in logged watersheds. Although variance is high, control watersheds show a tendency for the proportion of channel elevation drop accounted for by headcuts to increase with increasing catchment area (Fig. 4C), while logged watersheds show no significant increase (Fig. 4D). For channel segments with catchment areas larger than 10 ha, control watersheds show the mean proportion of elevation drop from headcuts to be 0.53 ± 0.09, compared to 0.26 ± 0.09 in logged watersheds.

Sample frequencies allow assessment of channel characteristics in reaches shorter than those required for headcut assessments. Comparisons of morphological attributes in 25-m channel reaches in control and logged watersheds show patterns similar to that of Fig. 4D: the systematic variations in width, depth, and cross-sectional

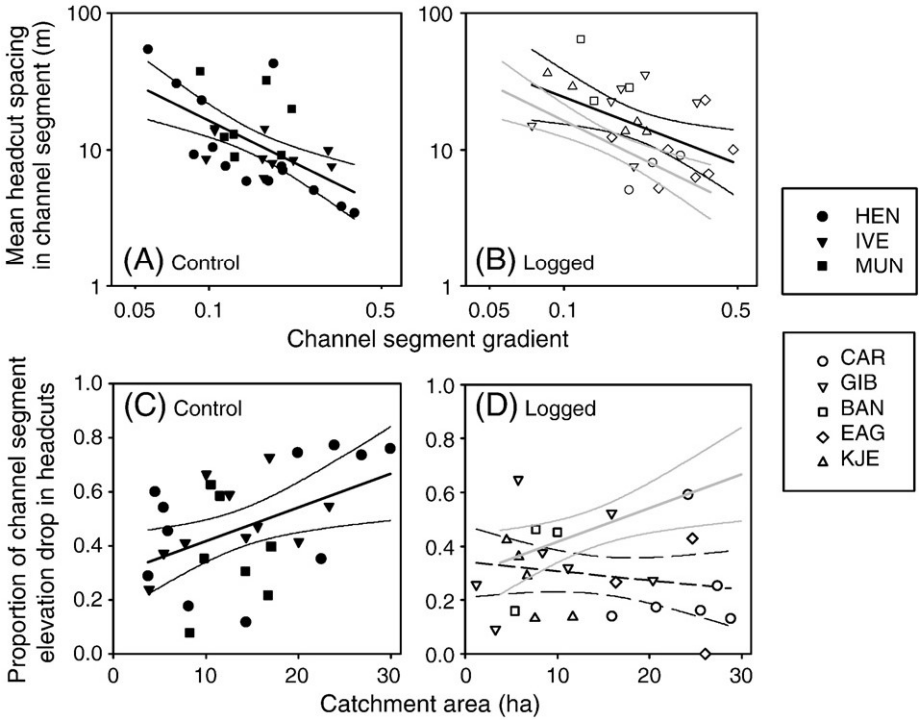

Fig. 4. Headcut spacing as a function of channel gradient in 50-m reaches of North Fork (A) control ($r^2 = 0.36$) and (B) logged ($r^2 = 0.23$) tributaries; and relative importance of elevation drop from headcuts in (C) control ($r^2 = 0.20$) and (D) logged ($r^2 = 0.03$) tributaries of North Fork Caspar Creek. The gray lines in Fig. 4B and D depict the regression and 95% confidence band for controls. Dashed lines indicate relations not significant at the 0.05 level.

area with stream power index expressed in control tributaries are not evident in recently logged tributaries (Fig. 5A). Relations between these attributes and watershed area, however, are strongly expressed in the pervasively gullied KJE tributary (Fig. 5B), in which gullies appear to have coalesced before monitoring began and which exhibits no significant relations to stream power index.

Results for South Fork tributaries, which were selectively logged in the early 1970s, are generally intermediate to those in North Fork logged and control watersheds. Headcut spacing in 50-m reaches and the proportional elevation drop accounted for by headcuts are most similar to those in logged North Fork watersheds (Fig. 6). Morphological data from South Fork tributaries generally show higher variance than found for either logged or control North Fork channels, which may in part result from the use of a l0-m DEM for the analysis rather than the 2-m DEM used for North Fork tributaries.

Mapping of upstream channel limits in North Fork control watersheds shows a mean stream power index of 0.69 ± 0.12 ha at the channel head (Fig. 7, Table 2). Results for the South Fork watershed (0.61 ± 0.09 ha) are not significantly different from those for North Fork control watersheds, while values for clearcut North Fork watersheds (0.34 ± 0.10 ha) are significantly lower than those in either control watersheds or South Fork tributaries. The catchment area at the head of forested channels averages 1.9 ± 0.3 ha, compared to 1.2 ± 0.5 ha for logged tributaries, representing a 28% increase in drainage density within 30-ha watersheds.

4.2. Rates of erosion at headcuts and streambanks

Measured rates of headcut retreat are highly skewed in part because of differences between activity levels at headcuts held in place by roots or woody debris and those not impeded by such features. Of the 52 headcuts observed over a four-year period in MUN, YOC, and ZIE tributaries, three migrated rapidly (>30 cm y^{-1}) during at least one year, for a total of 4.8 m during four headcut-years. The other 204 headcut-years produced no rapid retreat. The resulting mean rate of rapid retreat for all 52 monitored headcuts is 4.8 m for 208 headcut-years, or 2.3 cm y^{-1} per headcut.

For the subset of 11 headcuts that were surveyed in more detail between 2000 and 2002 or 2008, displacement totaled 158 cm over 64 headcut-years that exhibited no rapid retreat, producing a mean retreat of 2.5 cm y^{-1}. Individual retreat rates ranged from 0 to 30 cm y^{-1}, with two headcuts showing no retreat over the 8-year period. Recession monitored around painted roots over an 8-year period indicated an average retreat of 0.7 cm y^{-1} for 32 headcut-years. The combined estimate for gradual retreat is thus 1.9 cm y^{-1}, and the estimated total retreat rate is 4.2 cm y^{-1} with an expected accuracy of about $\pm 50\%$. Data are too few and variance too high to isolate the effect of the 25-year recurrence interval storm of December 2005. Field observations suggest that many of the changes in headcut location noted between 2002 and 2006 may have resulted from the storm, but that the storm did not cause widespread or severe channel disruption.

As is the case for headcuts, banks show a skewed distribution of rates. Two monitored banks eroded rapidly (6 and 8 cm y^{-1}), while eight showed rates of <1 cm/y; retreat averaged 1.6 ± 1.2 cm y^{-1}. Erosion generally occurred either by block failure–often associated with undercutting–or by more widespread but gradual backwasting and spalling.

4.3. Suspended sediment yields

Lewis (1998) demonstrated that, with the exception of KJE, storm-based sediment yields increased significantly above expected levels after logging; these patterns are evaluated in more detail by Lewis et al. (2001). For the present study, we evaluate annual yields to assess the relative importance of individual watersheds as sediment sources. Mean annual suspended sediment yields at North Fork tributary gaging stations range between 2 Mg km^{-2} y^{-1} at watershed BAN before logging and 68 Mg km^{-2} y^{-1} at KJE after logging (Table 3).

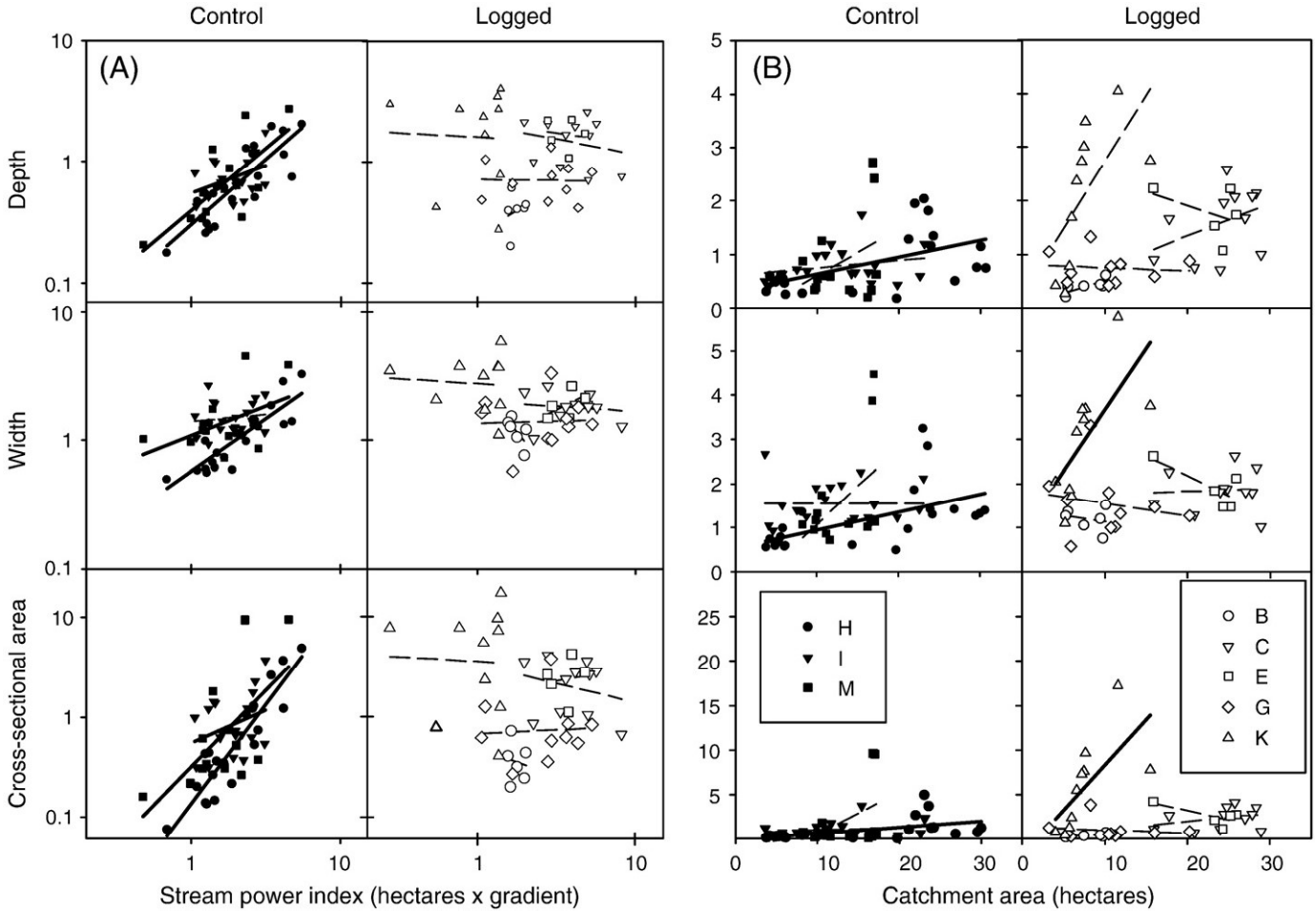

Fig. 5. Variation in mean segment depth (m), width (m), and cross-sectional area (m^2) with (A) stream power index and (B) catchment area in control and logged tributaries of North Fork Caspar Creek. Relations significant at the 0.05 level are depicted by solid lines.

4.4. Rates of erosion from other sources

Plot erosion data reported by Rice (1996) and here recalculated to reflect the post-calibration period reveal strong differences between logged and control watersheds. Logged watersheds show road and hillslope soil displacement rates averaging 2600 ± 1170 Mg km^{-2} y^{-1}, with 6 to 33% of the individual watershed totals associated with road erosion. In control watersheds, displacement averages about 8% of that calculated for the logged watersheds over the analogous period (Table 3), and 0% to 76% is associated with road erosion. Erosion on hillslope plots in control watersheds averages 67 ± 61 Mg km^{-2} y^{-1}. These calculations assume that all erosion voids are visible for 5 years in control watersheds. If the period of visibility is actually longer, as assumed by Rice (1996), the difference between displacements in logged and control watersheds would be accordingly greater. Hillslope and road erosion rates for the calibration period are highly uncertain. Differences in estimated displacement from roads during the calibration and post-calibration periods reflect the increase in road area in the treated watersheds and the expected influence of heavy road use in both treated and control watersheds. Overall, expected road sediment after the onset of road construction increased on average by factors of 16 in treated watersheds and 6 in controls.

Large-event surveys in the gaged watersheds disclosed 8 events capable of contributing sediment to streams during the calibration period and 25 in the post-calibration period. Mapped events were associated with major storms in 1986 (5 events), 1990 (4 events in two storms), 1993 (7 events), and 1995 (17 events in two storms). Field-based estimates for each of these events indicate that an average of about 25% of the sediment displaced was transported off-site. Annualized average volumes of off-site displacement from large events during the post-calibration period (Table 3) are not significantly different at the 0.05 level between treated watersheds (19 ± 14 Mg km^{-2} y^{-1}) and controls (26 ± 2 Mg km^{-2} y^{-1}).

5. Interpretation and discussion

Results of the field study are here interpreted to address three questions: (i) What is the relative importance of gully erosion between logged and forested tributary watersheds at Caspar Creek? (ii) How important is gully erosion relative to other sediment sources in the area? (iii) What mechanisms might contribute to differences in the extent and importance of gully erosion between logged and unlogged watersheds?

5.1. Sediment production from gully erosion in logged and forested tributaries

Once the distribution of channel characteristics and their associations with land-management categories are identified, it is possible to extrapolate information from the sampled portions of a watershed to the watershed as a whole. Measured headcut and bank erosion rates can then be applied to the channel network expected in each setting to allow comparison of average sediment production rates from gully sources typical of forested North Fork watersheds, recently clearcut

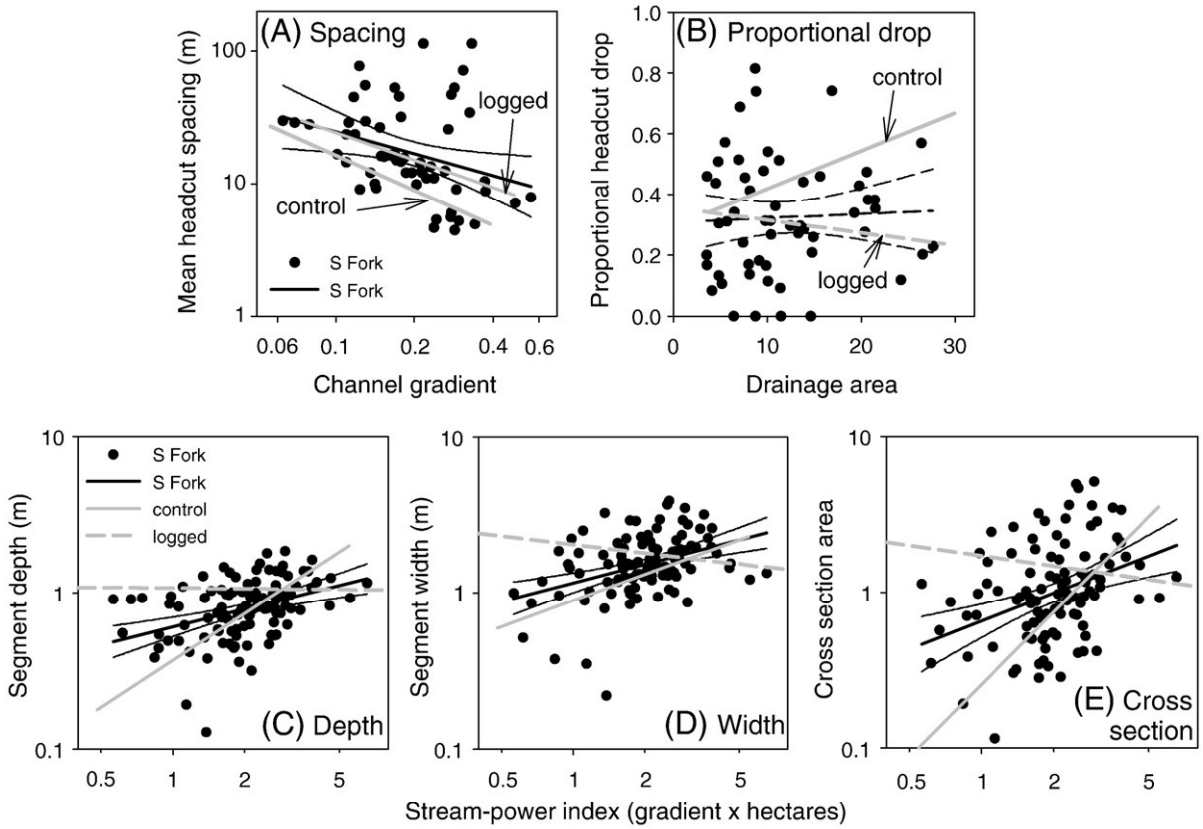

Fig. 6. Patterns of headcut distribution in South Fork tributary channels, and morphological characteristics of South Fork channels. Relations shown in gray depict analogous relations for North Fork tributaries (pooled regressions from Figs. 4 and 5), and relations significant at the 0.05 level are depicted by solid lines.

North Fork watersheds, and selectively logged South Fork watersheds. Calculations of sediment production from bank and headcut erosion are based on sparse data from a limited period, so estimates are not reliable. However, estimated sediment input rates are useful for indicating the potential magnitude of sediment contribution from the gullies and for assessing relative contributions among the three watershed treatment categories.

Sediment production by retreat of headcuts higher than 0.44 m in control watersheds can be estimated if we assume (i) the area of each eroding headcut face is equivalent to the product of the headcut height (relative to the base of the plungepool) and the channel width measured immediately downstream; (ii) the calculated average retreat rate of 4.2 cm y^{-1} for monitored headcuts applies to all headcuts higher than 0.44 m; and (iii) headcut frequency and dimensions in unmapped channels are similar to those in mapped reaches of similar size. Estimated sediment input from this source is then 28 Mg km^{-2} y^{-1} in North Fork control tributaries smaller than 30 ha (Table 2), with 19% of that sediment originating in channels draining areas of 1.9 to 3 ha, which were not characterized in control watersheds during the gully survey. Because headcut face areas are calculated as the product of channel width and the face height above the base of the plungepool, plungepool erosion is implicitly included as a component of headcut erosion.

A portion of the sediment eroded from headcuts and plungepools is deposited immediately downstream on the depositional downstream lip of the plungepool. Lip aggradation is estimated to account

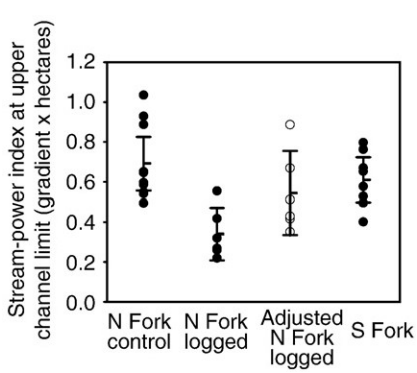

Fig. 7. Distribution of stream power indices at the upper limits of tributary channels. Error bars indicate the 95% confidence interval around the means (horizontal lines). "Adjusted" values account for hydrologic change after North Fork logging (see text Section 5.3.1).

Table 2
Comparison of channel characteristics for three watershed categories; dimensions represent means for 25-m channel segments; 95% confidence intervals are indicated for means.

Attribute	North Fork		South Fork
	Control	Clearcut[a]	
Catchment area at channel head (ha)	1.9 ± 0.3	1.2 ± 0.5	2.3 ± 1.0
Stream power index at channel head (ha)	0.69 ± 0.12	0.34 ± 0.10	0.61 ± 0.09
Channel width: mean at 3 to 7 ha (m)	0.97 ± 0.34	1.31 ± 0.38	1.37 ± 0.26
Channel width: mean at 15 to 25 ha (m)	1.83 ± 0.48	1.76 ± 0.25	2.16 ± 0.38
Channel depth: mean at 3 to 7 ha (m)	0.49 ± 0.07	0.53 ± 0.23	0.72 ± 0.11
Channel depth: mean at 15 to 25 ha (m)	1.16 ± 0.35	1.35 ± 0.40	1.02 ± 0.18
Estimated headcut erosion (Mg km^{-2} y^{-1})	28	50	37
Estimated plungepool deposition (Mg km^{-2} y^{-1})	7	12	9
Estimated bank erosion (Mg km^{-2} y^{-1})	54	73	66
1992–95 average suspended load (Mg km^{-2} y^{-1})	25 ± 17	39 ± 20	-

[a] Exclusive of watershed KJE.

Table 3
Estimated rates of sediment displacement and suspended sediment yields in North Fork sub-watersheds.

Site	Area (ha)	Years in category[a]	Suspended sediment yield	Road plot erosion[b]	Hillslope plot erosion[b]	Landslides and treethrows[c]	Gully erosion[d]
			($Mg\ km^{-2}\ y^{-1}$)				
Treatment watersheds, calibration period[a]							
BAN	10	6.1	2	0	67	0	52
CAR	26	6.1	6	44	67	0	90
EAG	27	4.7	8	6	67	3	68
GIB	20	4.9	9	58	67	27	82
KJE	15	3.8	67	5	67	0	136
Treatment watersheds, post-calibration period[a]							
BAN	10	3.9	9	330	1490	0	78
CAR	26	3.9	29	440	690	37	111
EAG	27	5.3	54	190	4290	31	90
GIB	20	5.1	29	510	2280	6	100
KJE	15	6.2	68	460	1680	20	142
Control watersheds, calibration period[a]							
HEN	39	5	14	0	67	11	82
IVE	21	5	9	44	67	1	74
MUN	16	5	21	6	67	0	77
Control watersheds, post-calibration period[a]							
HEN	39	5	30	0	33	24	82
IVE	21	5	7	1290	130	26	74
MUN	16	5	23	35	39	27	77

[a] "Calibration period" ends with the onset of new road construction at each logged watershed and after 5 years at each control watershed.
[b] Based on hillslope and road erosion plot measurements (Rice, 1996); values represent total amounts displaced.
[c] Based on landslides and treethrows mapped during channel surveys; values represent amounts transported off-site.
[d] Based on application of average bank and headcut erosion rate to the areas of bank and headcut face expected to be present in the watershed (see text); values represent amounts transported beyond the plungepool lip.

for approximately 25% of the combined headcut and plungepool erosion, as plungepool depths below the residual pool surface (i.e., below the depositional lip) average about 25% of the total headcut height on 23 headcuts mapped on the YOC-ZIE tributary in 2006.

We expect retreat rates for 0.26- to 0.44-m headcuts to be lower than 4.2 cm y^{-1} and rates to be negligible for faces shorter than 0.26 m. But even at a retreat rate of 4.2 cm y^{-1}, the expected population of 0.26- to 0.44-m headcuts in control tributaries would produce no more than 4 Mg km^{-2} y^{-1} of sediment if the assumptions listed above apply also to the small headcuts.

The monitoring results indicate an average bank erosion rate of 1.6 cm y^{-1}, a value similar to rates measured on vertical faces in a grassland gully in alluvial clay soils near Berkeley, CA (2 to 4 cm y^{-1}; Reid, 1989) and on near-vertical road-cut faces in a western Washington forest (1.6 cm y^{-1}; Reid, 1981), suggesting that the measured values are reasonable for the observed conditions. To estimate total sediment input from bank erosion in control watersheds, we assume (i) the proportion of banks "susceptible to erosion" is represented as the proportion mapped during a 1995 channel survey as either undercut or vertical and composed of either alluvium or colluvium; (ii) the estimated average gully-bank erosion rate of 1.6 cm y^{-1} applies to the entire area of bank susceptible to erosion; and (iii) the measured relations between channel depth, stream power index, and drainage area defined for 3- to 30-ha watersheds apply to the full estimated drainage density of channels draining catchments of 1.9 to 30 ha.

The 1995 maps of North Fork tributaries indicate that at that time approximately half of the channel length was susceptible to erosion, with no significant difference in values between control and logged tributaries. The relation for channel depth as a function of drainage area obtained by pooling the data shown in Fig. 5 for control watersheds was then used to estimate mean depth for each channel increment throughout a hypothetical 30-ha control watershed. The above assumptions produce an estimated annual input from bank erosion of about 54 Mg km^{-2} y^{-1} in the hypothetical watershed (Table 2).

About 9 Mg km^{-2} y^{-1} of the calculated amount, or 17%, is expected to be from unmapped channels with drainage areas of 1.9 to 3 ha and so is based on extrapolation of the defined relations to smaller watersheds. A second estimate for the unmapped low-order reaches may be made by assuming that channel form near the head of a clearcut tributary is similar to that near the head of a control tributary, despite the difference in drainage areas at the channel head. If the mean bank face height of 0.5 m calculated for a mapped 40-m reach draining 1.2 to 1.3 ha of clearcut is assumed also to represent that near forested channel heads, the input by bank erosion from 1.9- to 3-ha drainage areas in control watersheds is estimated to be 12 Mg km^{-2} y^{-1}, a value similar to that estimated using morphological extrapolations.

Similar calculations employing the same estimate of the proportion of erodible bank for channels characteristic of South Fork watersheds provide an estimated input of 37 Mg km^{-2} y^{-1} from headcut erosion and 66 Mg km^{-2} y^{-1} from bank erosion in a 30-ha watershed, values 32% and 22% higher than corresponding estimates for North Fork control conditions (Table 2).

If headcut and bank retreat rates measured in North Fork control channels and South Fork channels are assumed to apply also to North Fork logged channels (exclusive of KJE), such channels would supply expected inputs of 50 Mg km^{-2} y^{-1} from headcuts and 73 Mg km^{-2} y^{-1} from banks (Table 2), values 79% and 35% higher than corresponding estimates for control conditions. The high values for headcut inputs relative to those in controls largely reflect the increased headcut face area expected in the extended low-order channel network and are offset slightly by the increase in headcut spacing downstream. Higher input rates from bank erosion reflect increases in both channel length and depth. Possible increases in headcut and bank retreat rates after logging and in percentage of the bank susceptible to erosion were not considered, so these calculations may underestimate erosion from these sources in logged watersheds.

5.2. Contribution of gully erosion to the sediment yield

To assess the importance of gully erosion relative to other sediment sources, we first compare estimates of sediment production from gullies to those from other erosion processes. Such comparisons, though instructive, do not account for differences in sediment delivery to streams and through stream channels, so we then evaluate correlations between tributary sediment yields and potential controlling influences.

5.2.1. Comparison of gully erosion rates to those of other erosion processes

The importance of gullying to sediment production can be evaluated relative to rates and patterns of erosion from other sources if total gully erosion is estimated for the length of channel present in each gaged watershed of the North Fork catchment. This calculation differs from the previous one in that channel characteristics within individual watersheds are taken into account instead of using regressed relations to construct typical conditions in a hypothetical watershed.

Sediment input from channel-bank erosion is calculated as the product of eroding bank area and average bank erosion rate (1.6 ± 1.2 cm y^{-1}) and is converted to units of mass by applying an average bulk density for the characteristic soil (1.5 Mg m^{-3}). The area of eroding banks in unmapped portions of each tributary channel network is estimated by assuming (i) channel heads are located at a drainage area of 1.9 ha for pretreatment conditions and 1.2 for logged

conditions; (ii) regressions between channel depth and drainage area (Fig. 5) apply also to unmapped channels within each category of watershed; and (iii) 50% of the bank length is susceptible to erosion. Unmapped reaches (primarily first-order channels) account for 48% to 94% of the estimated channel length in individual North Fork watersheds (Table 1) and for an average of about half the estimated eroding bank area. Inputs from headcut erosion are calculated by applying an average retreat rate (4.2 ± 2.1 cm y^{-1}) to the estimated area of headcut face present in each tributary, using assumptions analogous to those employed for estimating bank erosion. Deposition on plungepool lips is then estimated as 25% of the volume eroded by headcut retreat and is subtracted from the total for each watershed.

Comparison of the estimated sediment inputs from gully erosion after logging to displacement rates estimated from road erosion plot data shows displacements from road erosion to average about 5 times greater than those accounted for by gully erosion (Table 3), and those calculated from hillslope erosion plot data to be an order of magnitude greater. Displacement from gullying, in turn, exceeds displacement from treethrows and landslides by a factor of 6.

Comparison of displacement rates to measured suspended sediment yields requires an estimate of the proportion of the total sediment load that is transported in suspension at the tributary gages. Bedload was not measured, but sediment volumes and particle sizes accumulated in the North Fork weir pond suggest that coarse sand and gravel transported as bedload contribute about 20 to 30% of the total clastic load at the North Fork weir. Comparison of the proportion of the sediment load accounted for by gravel at the weir (13%) to the proportion of gravel present in the upper 1 m of the watershed's dominant soils (25 to 50%) indicates that a high proportion of the gravel has broken down to smaller sizes before reaching the weir, suggesting that the proportion of sediment transported as bedload is likely to be substantially higher in tributaries. We here assume that 40% of the tributary sediment load is transported as bedload, so we expect total sediment loads to be about 67% higher than the suspended sediment yields noted in Table 3.

Comparison of rates of plot erosion with estimated total sediment yields demonstrates that sediment delivery rates for surface erosion sources are quite low, necessarily averaging <3% for logged watersheds. Field observations indicate that much of the sediment displaced on hillslopes is quickly redeposited on hillslopes, in low-order swales, or on valley flats and so does not contribute directly to sediment yield over the short term. Estimated sediment displacement from gully erosion is also more than sufficient to account for the total sediment loads, suggesting that deposition within channels and on valley flats may significantly influence the amount and timing of sediment exports from the tributary watersheds.

About half of the sediment from treethrows and landslides in the post-calibration period was generated during storms in HY 1995 and so would influence only a single year of the suspended sediment record for the period; most of the rest originated in 1993. Mean suspended sediment load for HY1995 in the logged watersheds was 83 Mg km^{-2}, so estimated total load averaged about 140 Mg km^{-2}. In comparison, sediment displaced by large events amounted to 63 Mg km^{-2} that year, suggesting that large events would not have provided the principal influence on sediment yield even during a year with a high incidence of landsliding.

In addition, examination of annual yields at tributary gaging stations indicates that ranks in suspended sediment yield were relatively consistent from year to year between 1991 and 1995 (Fig. 8), suggesting that yields during this period were largely controlled by chronic sediment sources rather than by discrete, sediment-producing events such as landslides. The highest rankings for tributaries were not associated with years in which significant landslides were observed in those tributaries.

The relative importance of landslides is likely to be greater over the long term because of the rare occurrence of very large slides. Between

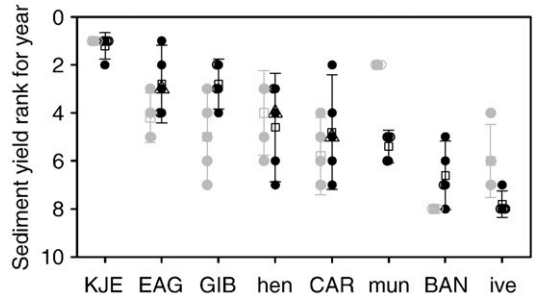

Fig. 8. Relative rankings in suspended sediment yield at tributary gages for HY1986–1990 (gray symbols) and HY1991–1995 (black). Open squares indicate mean rank for the period, and data points for years with significant landslides within individual watersheds are enclosed in triangles. Upper-case gage names indicate logged tributaries.

1986 and 2006, for example, total sediment displacement from landslides and near-stream treethrows throughout the North Fork watershed averaged over 200 Mg km^{-2} y^{-1}, and the two largest slides were responsible for about 50% of the displacement. Had the period of extensive suspended sediment monitoring (1986–1995) included one of these major landslides, landsliding would have undoubtedly influenced short-term sediment yields; but results here suggest that influences from the landslides and treethrows mapped during the study period are not expressed as acute short-term increases in yield. Both of the largest slides occurred on logged slopes and triggered debris flows, resulting in considerable volumes of deposition within and adjacent to downstream channels. Such deposits are likely to be remobilized later by channel incision, thus eventually contributing additional suspended sediment through gully erosion.

5.2.2. Correlation analysis

The relative importance of various sediment sources can be further evaluated by analyzing correlations between sediment displacement rates and suspended sediment loads in the gaged watersheds to identify the combination of source inputs that best explains the observed distribution of yields. Irrespective of sediment delivery ratios and grain size distributions, the relative distribution of suspended sediment yields among watersheds is expected to reflect the relative distributions of sediment displacements from the processes that most strongly influence sediment yields. For this analysis, accuracy of the estimated sediment inputs is not as important as the relative values between watersheds within a source type.

We carried out a step-wise multiple regression of mean suspended sediment yields (SSY, Mg km^{-2} y^{-1}) from calibration and treatment periods in each tributary watershed against estimated erosion from gullies (G, Mg km^{-2} y^{-1}), large events, road plot erosion, hillslope plot erosion (P_h, Mg km^{-2} y^{-1}), and watershed area to evaluate the relative influence of these factors on the distribution of suspended sediment yields. The resulting model (Fig. 9) employs only two variables:

$$SSY = -41.5 + 0.702G + 0.0050P_h \quad \text{adjusted}\, R^2 = 0.77 \qquad (1)$$

The relation is highly significant at the 0.05 level, with gully erosion by itself explaining 73% of the variance; the hillslope term is only marginally significant ($p = 0.05$). Results suggest that gullying and associated processes in logged watersheds contribute about three to seven times as much sediment to the sediment yield as processes assessed by hillslope erosion plots. In forested watersheds the difference is greater, with gullying responsible for about 50 to 200 times as much as hillslope erosion. Delivery of hillslope sediment to streams depends in part on the extent of the channel network, so the

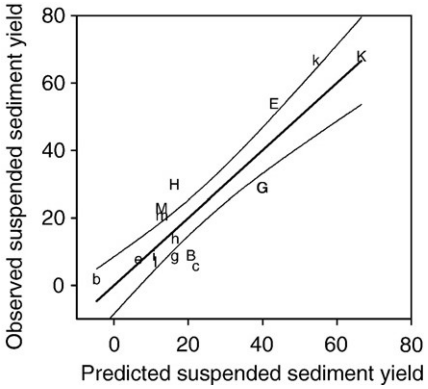

Fig. 9. Observed suspended sediment yields (Mg km^{-2} y^{-1}) versus those predicted using Eq. (1). Lower case initials represent data for the calibration period in each watershed. Points C and G are superimposed.

apparently overwhelming importance of gully erosion may actually reflect both in-channel erosion and the increased efficiency of hillslope sediment delivery due to network expansion after logging.

If bedload is assumed to account for 40% of the total sediment yields at the tributary gages, about half the estimated sediment eroded from banks and headcuts is not delivered to the downstream gage, suggesting that either the rate of gully erosion is overestimated or that significant deposition is occurring within channels and on floodplains. An average channel aggradation rate of 2 mm y^{-1} would account for the undelivered sediment, and if aggradation is indeed occurring at this rate it should become evident from cross-section measurements in the near future. However, given the uncertainties associated with the rate calculations, we expect that imprecision in estimated rates is likely to account for most of the discrepancy.

5.3. Mechanisms of influence from logging

Results of the study suggest that clearcut logging at Caspar Creek caused a significant increase in gully-related sediment inputs (Table 2). Such increases might reflect either increased runoff associated with logging or direct disturbance of low-order channels during cable-yarding operations. Several kinds of information suggest that hydrologic change is likely to be the dominant influence in the present case.

5.3.1. Evidence from network extent

Field measurements suggest that channel heads migrated upslope after logging (Fig. 7, Table 2) and that the stream power index associated with the channel head locations is significantly lower in logged watersheds than in controls. However, the utility of the stream power index (calculated as drainage area × gradient) as a measure of actual stream power relies on the assumption that drainage area is a valid index for relevant discharges. Once a site is logged, the relation between drainage area and characteristic discharges changes.

In North Fork watersheds, the mean peakflow for flows with recurrence intervals longer than 0.15 y increased by about 60% in the 2 years following logging (Reid and Lewis, 2007), with increases approaching an asymptote of 34% for flows occurring fewer than 3 times a year. Effective maximum stream power per unit drainage area during storms thus averaged 60% greater after logging, so a post-logging stream power index of 0.34 ha is equivalent to a pre-logging index of 0.54 ha. If this hydrologic shift is accounted for, the recalculated index at the channel head is not significantly different at the 0.05 level between logged and control watersheds (Fig. 7).

This finding may indicate either that the hydrologic change is sufficient to explain the shift in channel-head location or that the hydrologic change prevented healing of mechanically disrupted sites over the period following yarding. Low-order tributaries are most susceptible to influences from direct disturbance, and the prevalence of subsurface soil pipes in headwater channels would make these sites particularly sensitive to mechanical disruption. However, changes in channel characteristics in logged watersheds along the 65% of the mapped channel length protected by buffer strips could not be explained by direct disruption because disturbance within the buffers is minimal.

5.3.2. Evidence from nested gages

If hydrologic change is an important influence on in-channel erosion after logging, channels downstream of logged watersheds should show increases in sediment yield that cannot be explained simply by changes in sediment input from upstream.

A pair of nested stream gages provides the data needed to assess downstream variations in sediment yield in a gullied tributary. Gage DOL (with a 77-ha catchment) lies downstream of gage EAG (27 ha) in the North Fork watershed. The catchment above the EAG gage was logged in 1991, and hillslopes abut most of the channel length in the EAG catchment. In contrast, the catchment between the EAG and DOL gages has not been logged since 1904, and valley-fill terraces buffer much of the channel from hillslope inputs. Several small tributaries enter this reach, but alluvial fans at most tributary mouths appear to trap much of their coarse sediment load and some fine sediment. Visible sources of sediment within the reach include incised stream banks, headcuts, and near-stream treethrows.

Suspended sediment loads measured during storms at the EAG gage were subtracted from corresponding loads at the DOL gage to estimate the load derived from the unlogged portion of the watershed. Loads for the pre-logging period in both portions of the watershed were then regressed against the mean of loads at control watersheds HEN and IVE to allow prediction of expected loads. The ratios of observed to expected loads from the unlogged portion of the watershed show a response similar in initial timing and magnitude to that from the logged portion of the watershed (Fig. 10), though the downstream portion reattained pre-logging values more quickly than the logged portion. Sediment input increased again in the DOL reach after regrowth in the EAG watershed was thinned in 2001. The sediment record thus indicates that upstream logging influenced sediment production in unlogged portions of the downstream watershed where there was no direct disturbance, suggesting that hydrologic change may indeed have been influential.

However, it is also possible that a portion of the sediment appearing to have originated within the DOL reach may represent

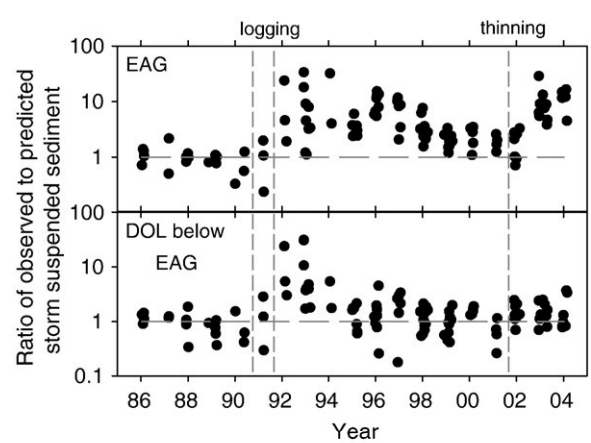

Fig. 10. Deviations from expected suspended sediment load in the clearcut EAG watershed and in the unlogged portion of the DOL watershed downstream of the EAG gage. Values are corrected for bias from back-transformation from logarithms (Baskerville, 1972).

breakdown of bedload into suspendible sizes: bedload originating in EAG would not be included as part of the EAG suspended load, but if it then becomes suspendible downstream it would be recorded as suspended load at the DOL gage. The potential magnitude of this effect can be estimated if bedload is assumed to represent 40% of the total sediment load at EAG. DOL produced 197 Mg of excess suspended sediment between 1991 and 1995, compared to 38 Mg from EAG, indicating that breakdown could explain no more than 13% of the post-logging sediment increase from DOL even if all EAG bedload were transformed to suspended load within the DOL channel. In actuality, much of the EAG bedload is trapped on a minimally channeled fan immediately downstream of the gaging station, so breakdown is likely to explain substantially less than 13% of the increase.

At a larger scale, Lewis et al. (2001) evaluated post-logging changes in suspended sediment yield across the full suite of nested North Fork stream gages and found that observed changes in suspended sediment yield after logging were more closely correlated with changes in flow than with other indices of management activity levels.

5.3.3. Morphological changes associated with headcut migration

Results of morphological comparisons for logged and control tributaries also are consistent with a situation in which channel morphology has been influenced by increased flows after logging. Contrasts in morphology between logged and control watersheds are revealed not so much by changes in average channel dimensions as by changes in the relations between channel dimensions and controlling variables such as stream power and drainage area (Fig. 5), and by increased spacing between headcuts after logging (Fig. 4).

The contrasting patterns may reflect an increase in the frequency with which headcuts are destabilized after logging. Newly mobilized headcuts can retreat rapidly until they encounter an upstream plungepool or a hardened lip supporting another headcut. Two discontinuous gullies will then have coalesced, thereby decreasing the number of headcuts present and increasing mean headcut spacing while not strongly affecting headcut height. Mean channel cross-sectional area would increase in areas where gullies coalesce. Reaches experiencing large changes in any particular year are likely to be distributed randomly, as the ability for a headcut to retreat rapidly is strongly influenced by the condition of elements armoring its lip. Overall patterns of distribution for morphological characteristics are thus likely to become less regular as the system continues to adjust to the sequence of changing hydrologic conditions.

Increased coalescence of headcuts in logged tributaries is also consistent with observed differences in the relative importance of stream power and watershed area as predictors of morphological characteristics in control watersheds and in the pervasively gullied watershed KJE (Fig. 5). In general, where gullies are present as a series of headcuts, headcut location–and the resulting distribution of incised reaches–might strongly reflect local conditions. For a channel segment with uniform discharge, incision is expected to persist along the steeper portions (high stream power), while low-gradient portions (low stream power) may aggrade. In contrast, where gullies have coalesced, incised reaches also span low-gradient reaches between initial headcut locations. Because the fine-scale patterns of incision and deposition in discontinuous gullies are superimposed on the broader pattern of a general increase in channel size downstream, which persists when gullies coalesce, stream power would then become a less efficient predictor of attributes such as width, depth, and cross-sectional area than would drainage area alone.

Morphological characteristics associated with reaches having low headcut frequencies are expected to diverge between logged and control watersheds as logged channels adjust to altered conditions. If low frequencies in logged reaches indicate coalescence of headcuts rather than absence of incision, mean channel depths in reaches with few headcuts should be greater in logged watersheds than in control watersheds, and this is indeed the case. In channel segments where headcut frequency is less than about 10/100 m of channel, mean channel depth is significantly greater in logged watersheds (1.6 ± 0.4 m) than in control watersheds (0.7 ± 0.2 m, Fig. 11). In the South Fork watersheds, the distribution of channel depths as a function of headcut spacing is most similar to that in North Fork control watersheds.

5.4. Contrasts between North Fork and South Fork channels

The intermediate position of South Fork channel morphological relations relative to those in North Fork control and clearcut watersheds (Fig. 6) may in part reflect ongoing recovery from second-cycle logging effects in the South Fork. The South Fork was logged 28 to 30 years before the gully survey, while North Fork watersheds had been logged only 10 to 12 years earlier. Differences in silvicultural strategy and yarding techniques would also contribute to differing results. The selective logging employed in the South Fork resulted in less hydrologic change from altered vegetation than in the clearcut North Fork watersheds, but the use of tractors for yarding produced widespread compaction that continues to generate overland flow at some sites. In addition, South Fork logs were skidded along some low-order channels, directly disrupting the channels and likely producing a very different distribution of channel forms immediately after logging than was present after North Fork logging. Also in contrast to the North Fork, South Fork roads and landings were located mid-slope and in riparian zones, strongly

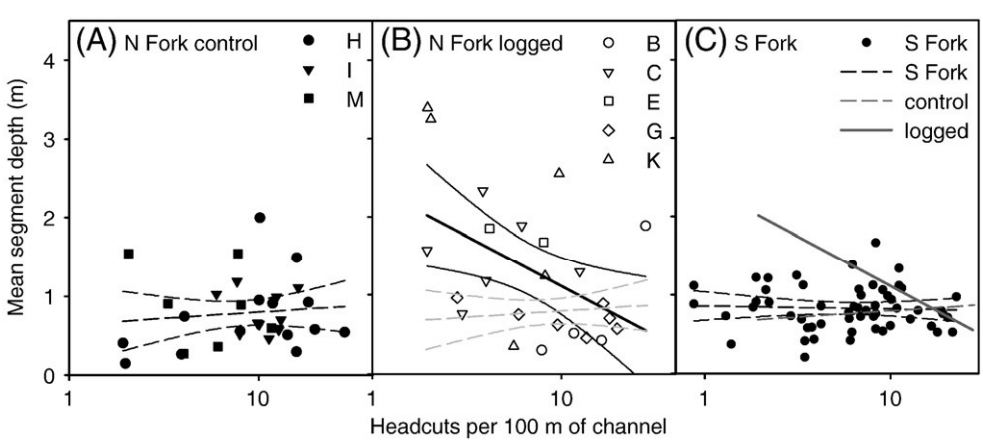

Fig. 11. Mean depth and headcut frequency in 50-m channel segments of (A) North Fork control, (B) North Fork logged, and (C) South Fork tributaries. Relations significant at the 0.05 level are depicted by solid lines.

increasing the potential for channel disruption by road drainage and mechanical disturbance.

5.5. Implications for forest management

Efforts to prevent and mitigate logging-related erosion in rain-dominated watersheds of the Pacific Northwest have generally relied on the use of buffer strips and on reduction of road-related erosion. Road erosion was found not to be of major consequence at North Fork Caspar Creek (Lewis et al., 2001), possibly reflecting drainage control efforts, road closures following logging, and pervasive water-barring of abandoned roads. Most North Fork roads and log landings are located near ridge tops, further reducing their potential for contributing sediment directly to channels. Robust buffer strips were incorporated into the logging plan, providing extensive filter strips below upland sediment sources and preventing direct disturbance to a significant portion of the stream network. Despite these measures, suspended sediment yields increased significantly after logging, and much of the increase appears to originate from gully-related processes that are not amenable to mitigation either through road improvements or buffer strips. If increased runoff after logging generates sediment from within downstream channels, control of excess sediment from this source would be possible only through management of the level of hydrologic change induced by logging, and this would require either management of the rate of logging within a watershed or modification of the silvicultural strategy used.

Logging prescriptions generally consider only the distribution of channel types present at the time that plans are developed and so do not reflect the possibility that the channel network may expand after logging. The apparent 28% increase in drainage density after logging at Caspar Creek would strongly increase the connectivity between hillslope sediment sources and the downstream channel network. Plans to maintain a prescribed distance between ground-disturbing activities and stream channels are defeated if channel networks expand into the disturbed sites after logging.

Logging plans on lands administered by US Federal agencies or regulated by California State agencies are required to include an evaluation of potential cumulative and indirect impacts of the planned logging, but considerable uncertainty and controversy have at times surrounded the definition of what constitutes an adequate impact analysis. Observation of the Caspar Creek gullies suggests that future analyses might usefully consider the possible influence of logging-related hydrologic changes on downstream channel morphology and sediment inputs.

Interest is growing in the use of indirect methods for inferring long-term erosion rates to allow comparison to management-related sediment inputs. Several studies have evaluated concentrations of cosmogenic ^{10}Be in soils and sediment to estimate long-term input rates (e.g., Kirchner et al., 2001). In the case of Caspar Creek, Ferrier et al. (2005) used results of such a study to conclude that recent erosion rates evaluated from monitoring data at Caspar Creek are lower than rates characteristic of the pre-logging period. Such conclusions rest heavily on the assumption that the distribution of sediment sources that produced the sampled sediment is typical of the distribution present over the period for which long-term rates are to be inferred. However, examination of the Caspar Creek tributaries indicates that gullying is now pervasive, that it probably initiated with or was greatly accelerated by first-cycle logging, and that many of the gullies excavate cosmogenically “pristine” sediment sources such as buried saprolite and bedrock. Under these conditions, samples obtained from in-channel sediments will contain lower ^{10}Be concentrations than would be expected from sediment exported before gully initiation, and estimated “long-term” erosion rates may instead disproportionately reflect accelerated erosion resulting from first-cycle logging.

6. Conclusions

Results of the Caspar Creek study suggest that erosion along incised channels is an important source of sediment in tributary watersheds. Gullying in the area appears to have expanded with first-cycle logging of the late 1800s. Channels had not yet recovered from the earlier impacts at the onset of second-cycle logging nearly 100 years later, and increased runoff resulting from second-cycle logging accelerated erosion within the still-incised channels. Recently logged watersheds show a higher drainage density than controls, with the extent of the increase similar to that expected on the basis of the observed change in runoff.

Because an appreciable portion of the increased sediment input at Caspar Creek is associated with hydrologic changes caused by logging and because a significant portion of the excess sediment is generated along channels in and downstream of the logged areas, the strategies most often used in the region to reduce sediment inputs from logging–control of road-related erosion and establishment of riparian buffer strips–are not effective for reducing an important component of the logging-related sediment input at Caspar Creek. In addition, efforts to reduce impacts from surface erosion by ensuring that soil-disturbing activities are not carried out near streams would need to take into account the potential for upslope expansion of the channel network after logging.

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ORGANIZED VILLAGE OF KASAAN

P. O. Box 26-Kasaan ※ Ketchikan, Alaska 99950-0340
(907) 542-2230 ※ (fax) 907-542-3006

RESOLUTION OVK-19-10-001

A Resolution of the Organized Village of Kasaan in support of the 'no-action alternative' as the as the preferred alternative in the Tongass National Forest Roadless Rulemaking process.

WHEREAS, the Organized Village of Kasaan is a federally recognized Tribe organized pursuant to the Indian Reorganization Act of June 18, 1934 (48 Stat. 984) and May 1, 1936 (49 Stat. 1250); and

WHEREAS, the Corporate Charter of the Organized Village of Kasaan (Ratified October 15, 1938) states in its Purpose and Existence, "In order to further the economic development of the Indians residing in the neighborhood of Kasaan, Alaska, by conferring upon the Organized Village of Kasaan corporate rights and powers; and to enable this Village and its members to undertake enterprises designed to secure for the members of the corporation an assured economic independence..." and

WHEREAS, the Organized Village of Kasaan (hereinafter "OVK") is governed by a Council of elected representatives composed of a President and six members who act in accordance with the powers granted to it by its Constitution and By-Laws (Ratified on October 15, 1938); and

WHEREAS, the OVK's traditional territory includes lands within and around the Tongass National Forest; and

WHEREAS, protection of the inherent right to harvest and use tribal traditional and customary foods and resources requires careful cultural stewardship and protection of tribal traditional environmental and national resources; and

WHEREAS, indigenous peoples' longstanding care of the ancestral lands now classified as "inventoried roadless areas" (IRA) and within the Tongass National forest has been in place for millennia and these lands not only provide indigenous people with food, they define who we are and where we come from; and

WHEREAS, inventoried roadless areas protect healthy watersheds which provide cold, clean water that has sustained Tribal ways of life since time immemorial and inventoried roadless areas contain many sacred sites integral to Tribal spiritual, religious, and traditional practices; and

ORGANIZED VILLAGE OF KASAAN

[illegible]

RESOLUTION 09-[illegible]

A Resolution of the Organized Village of Kasaan in support of the nomination nominating [illegible] as the [illegible] preferred [illegible] in the [illegible] Tongass National Forest Roadless Rule Petition process.

WHEREAS, the Organized Village of Kasaan is a federally recognized Tribe representing [illegible] in the Indian Reorganization Act of June 18, 1934 (48 Stat. [illegible] May 1, 1936 (49 Stat. 1250); and

WHEREAS, the Corporation [illegible] the Haida Village of Kasaan (Haida Corporation [illegible]) states in its Purpose [illegible] to [illegible] the economic development of the Indians residing in the [illegible] of Kasaan, Alaska by [illegible] the Haida Village of Kasaan corporate rights [illegible] and to enable the village and its members to [illegible] enterprises designed to [illegible] the economic [illegible] of the corporation [illegible] of economic independence; and

WHEREAS, the [illegible] of Kasaan (hereinafter "[illegible]") is governed by a Council of elected representatives [illegible] President and six members who [illegible] performance of the powers granted to it by [illegible] and by laws (Ratified on October 15, 1939); and

WHEREAS, the OVK's [illegible] include lands within and around the Tongass National Forest; and

WHEREAS, protection [illegible] to preserve and [illegible] tribal traditional land use [illegible] lands and resources requires [illegible] and advocacy for protection of tribal traditional environmental and cultural [illegible]; and

WHEREAS, indigenous [illegible] according [illegible] of the ancestral lands are classified as "inventoried roadless areas" [illegible] within the Tongass National Forest are open to plans for utilization and [illegible] these lands [illegible] indigenous people [illegible] land, they reflect who we are and who we [illegible];

WHEREAS, [illegible] are a perfect habitat [illegible] which provide [illegible] clean water [illegible] and [illegible] life [illegible] and contribute [illegible] contain many sacred sites [illegible] spiritual and [illegible] cultural [illegible]

WHEREAS, inventoried roadless areas conserve natural diversity and help ensure the continued protection of indigenous fish and wildlife habitat as it relates to our spiritual, social, nutritional, and ecological values; and

WHEREAS, given Southeast Alaska's cool, wet weather, the amount of stored carbon in our intact old-growth forest and soils, the Tongass National Forest represents one of the highest carbon stores in the world and the conservation of intact inventoried roadless areas on the Tongass is essential for slowing down climate change throughout the world; and

WHEREAS, according to the State of Alaska's own economic experts, Tongass timber is uncompetitive because of permanent and fundamental changes in global timber markets, high labor costs, distance from markets, and less expensive substitutes and the Tongass timber industry represents less than one percent of today's jobs and earnings in Southeast Alaska; and

WHEREAS, at hearings held across Southeast Alaska in 2000 on the proposed roadless rule, nearly 60 percent of the Southeast Alaskans who spoke at the hearings supported including the Tongass National Forest in the final roadless rule, and has only grown to upward of 80 percent to date; and

WHEREAS, any rule that weakens or eliminates Roadless Rule protections within Tribal traditional territory of the Tongass National Forest will substantially affect OVK's and the rest of the Southeast Tribes' inherent Tribal rights to traditional and customary uses of the land.

NOW THEREFORE BE IT RESOLVED, that the OVK Tribal Council strongly supports lasting protection for inventoried roadless areas within the Tongass National Forest as provided in the 2001 Roadless Rule; and

BE IT FURTHER RESOLVED, that the Organized Village of Kasaan Tribal Council requests that the Secretary of Agriculture to select the 'no-action alternative' as the preferred alternative in the Tongass National Forest, Alaska – Roadless Rulemaking process.

CERTIFICATION

APPROVED, PASSED AND ADOPTED by a duly constituted quorum of the OVK Tribal Council on this 17th day of October 2019; by a Roll Call Vote: Marina Anderson, yes; Michael Chilton, yes; Della Coburn, yes; Glenn Hamar, yes; and Paula Peterson, absent; Dorothy Smith, yes.

Ronald Leighton – President

ATTESTED:

Paula Peterson – Acting Council Secretary

WHEREAS, inventoried roadless areas conserve natural diversity and help ensure the continued protection of indigenous fish and wildlife habitat as it relates to our spiritual, social, nutritional, and ecological values; and

WHEREAS, given Southeast Alaska's cool, wet climate, the amount of sacred cedar in our intact old-growth forest and wild, the Tongass National Forest represents one of the biggest carbon stores in the world and the conservation of pristine inventoried roadless areas on the Tongass is essential for slowing down climate change throughout the world; and

WHEREAS, according to the State of Alaska's own economic experts, Tongass timber is uneconomic timber because of government and fundamental changes in global lumber markets, high labor costs, distance from markets, and less expensive substitutes and the Tongass timber industry represents less than [illegible] percent of today's jobs and earnings in Southeast Alaska; and

WHEREAS, at hearings in [illegible] Southeast Alaska in 2000 on the proposed roadless rule, nearly 60 percent of the [illegible] Alaskans who spoke at the hearings supported including the Tongass National Forest in the final roadless rule, and has only grown to approval of 60 percent to date; and

WHEREAS, any rule that [illegible] or eliminates Roadless Rule protections within Tribal traditional territory of the Tongass National Forest will substantially affect OVK's and the rest of the Southeast Tribes' inherent human rights to traditional and customary uses of the land.

NOW THEREFORE BE IT RESOLVED that the OVK Tribal Council strongly supports lasting protection for inventoried roadless areas within the Tongass National Forest as provided in the 2001 Roadless Rule; and

BE IT FURTHER RESOLVED that the Organization of Kake Tribal Council requests that the Secretary of Agriculture [illegible] the "no-action alternative" as the preferred alternative in the Tongass National Forest [illegible] – Roadless Rulemaking process.

CERTIFICATION

APPROVED, ADOPTED AND AUTHORIZED by a duly constituted quorum of the OVK Tribal Council on this [illegible] day of [illegible], 2019, by a Roll Call Vote: Marine Anderson, [illegible] Hunnell, Clinton [illegible]; Ruth Johnson, [illegible]; Gene Hanson, [illegible] and Paula Peterson, [illegible]; Dorothy Smith, [illegible].

Ronald Leighton – President

ATTESTED:

Paula Peterson – Acting Council Secretary

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A review of environmental impacts of winter road maintenance

Hrefna Run Vignisdottir[a,*], Babak Ebrahimi[c], Gaylord Kabongo Booto[a], Reyn O'Born[d], Helge Brattebø[b], Holger Wallbaum[c], Rolf André Bohne[a]

[a] Norwegian University of Science and Technology, Department of Civil and Environmental Engineering, Høgskoleringen 7a, 7491 Trondheim, Norway
[b] Norwegian University of Science and Technology, Department of Energy and Process Engineering, Sem Sælands vei 7, 7491 Trondheim, Norway
[c] Chalmers University of Technology, Department of Architecture and Civil Engineering, Sven Hultins Gata 6, 412 96 Gothenburg, Sweden
[d] University of Agder, Department of Engineering Science, Jon Lilletunsvei 9 Grimstad, Norway

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ABSTRACT

The need for winter road maintenance (WRM) is changing in cold regions due to climate change. How the different modes of WRM will contribute to future overall emissions from infrastructure is therefore of great interest to road owners with a view to a more sustainable, low-carbon future. In the quest for near-zero-emissions transport, all aspects of the transport sector need to be accounted for in the search for possible mitigation of emissions. This study used 35 peer-reviewed articles published between 2000 and 2018 to map available information on the environmental impacts and effect of WRM and reveal any research gaps. The articles were categorized according to their research theme and focus. They were found to focus mainly on the local effects of WRM with emphasis on effects on water. Of the reviewed works, 27 contain information related to the environmental effects of deicers on a local level while five focused on global impact, which was mainly caused by fuel consumption. Only two articles took a holistic look at the system to identify emission sources and the effectiveness of possible changes in operations methods or material selection. In conclusion, WRM would benefit from further research to understand how it affects the natural environment in regions with a cold climate. Furthermore, a life-cycle approach could reveal ways to mitigate emissions through effectively comparing possible changes in the system without shifting the problem to other aspects of road transport.

1. Introduction

To achieve the goal of keeping the rise in the global average temperature well below 2 °C (United Nations, 2015), greenhouse gas (GHG) emissions from all sectors of society, including transportation, must be drastically reduced. The transportation sector is estimated to be responsible for over a quarter of GHG emissions in Europe (Chapman, 2007; EC, 2015), and approximately 14% of total global GHG originate from road transport (Pachauri et al., 2014). The road transport sector contributes to a series of other global and local environmental impacts including stratospheric ozone depletion, acid deposition, and emissions of particulate matter (PM) and toxic chemicals, among others (Colvile et al., 2001; Lewis, 2018). The demand for mobility today is high and is estimated to rise further in the coming decades (Chapman, 2007; Schafer and Victor, 2000; Wang et al., 2006).

Road transportation can be divided into several life cycle phases where each phase pertains to different activities. Life cycle phases of road transport are the design phase, construction phase, use phase, operation and maintenance phase and, finally dismantling. Each phase has different emission profile and contribute to the life cycle emissions of the road to a different extent. On roads with a high volume of traffic, i.e. more than 20,000 average annual daily traffic (AADT), direct emissions from traffic (use phase) form the single largest source of GHG emissions. However, the extraction, production and transport of materials for construction of the road is the largest contributor on a lower traffic volume road with AADT 3000 (Santos et al., 2015; Zhang et al., 2010b). The emphasis in the literature has been on vehicle technology and emission reduction from road traffic (EC, 2015; Lombardi et al., 2017). This may be explained by the fact that there has been more research on heavily-trafficked roads and it is clear that traffic is the largest contributor towards global warming (Liljenström, 2013). Electric, hybrid and other vehicles using fuel solutions other than conventional fossil fuels emit less GHG while driving on the road. Comparing the different energy carriers and different vehicle technologies is important to discover how on-road emissions can be reduced. It has been shown that a switch towards hybrid solutions such as plug-in gasoline/

Abbreviations: GHG, Greenhouse gas; WRM, Winter road maintenance; PM, Particulate matter; LCA, Life cycle assessment; LC, Life cycle

* Corresponding author.
E-mail address: hrefna.vignisdottir@ntnu.no (H.R. Vignisdottir).

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electric hybrid and plug-in fuel cell/battery vehicles would provide opportunities for emission reduction (Lombardi et al., 2017).

Several stakeholders are involved in any road transport including road users, owners and operators, as well as road construction and maintenance workers. Road owners are usually national or local public authorities that are responsible for road construction and maintaining road infrastructure. The cost of constructing new and maintaining existing infrastructure often takes a considerable share of annual budgets (Zhang et al., 2010b). The high costs reflect the importance of the infrastructure's durability. The main factors affecting durability are the traffic load and climatic conditions (Liao et al., 2018). Low temperatures and frequent freeze-thaw cycles coupled with long winters significantly affect the service life of the road and its maintenance needs. Additionally, road infrastructure in such climates is often treated with anti- and de-icing chemicals (henceforth 'deicers') which further damage the infrastructure (ibid). Calculations of emissions during road construction which compare the different materials used (Birgisdóttir et al., 2006) as well as emissions from road construction machinery (Ebrahimi et al., 2018) have been investigated. While Birgisdóttir et al. (2006) do not focus on winter maintenance specifically, they include it in their study with the quantity of deicer and fuel used during winter maintenance operations.

The above studies show that decisions made early on in the design process can be very beneficial from the environmental point of view. This is supported by papers on road alignment and its effects on traffic emissions (Booto et al., 2017; Mauro and Guerrieri, 2016). Furthermore, looking carefully at climate factors before designing a road can make it possible to improve its longevity and reduce the frequency of both pavement and structural maintenance. During the lifetime of a road, operational maintenance including lighting, cleaning, road-marking and the provision of road rails and signs is also necessary.

Cold regions additionally need WRM to ensure adequate services for road users. The general goal of WRM is to ensure mobility and traffic safety, limit environmental effects, provide good service and care for the road infrastructure capital that exists (Guesdon et al., 2016; Min et al., 2016; NPRA, 2014; Shi et al., 2013). In cold regions, WRM is extensive with regard to both time and material use. WRM ensures safe mobility by increasing friction and road visibility. Friction between the tire and the pavement is essential for control of the vehicle and affects acceleration, breaking distance and directional control. Friction control is achieved by either applying de-icing chemicals or sanding, with chemicals employed mostly on heavily-trafficked roads while sanding is more common on roads with lower volumes of traffic (Norem, 2009).

Accidents on winter roads are quite common, and 16% of total fatalities on Norwegian roads during 2005–2012 were considered to be due to weather and driving conditions (NPRA, 2013). In Canada the proportion of fatalities considered to be due to adverse road conditions was close to 12% (2014); however, local variability is high, and on a per capita level fatalities are twice as high in Canada as in Sweden (Kelsall and Redelmeier, 2016). The main reasons for such accidents are often rooted in human behavior, with drivers failing to adjust their speed in accordance with the reduced friction on the road (Norrman et al., 2000).

WRM is the action of keeping roads open and safe for traffic and includes operations such as snow removal and ice control. WRM has changed over past decades in line with the increasing demand for mobility. Mostly this is in response to users' expectations of the service provided; i.e. the frequency of road clearing and how soon the road should be snow- and ice-free after a weather event (Andersson, 2016; Jónsson, 2017; Kelsall et al., 2016). This increase in demand for WRM has resulted in growing emissions and the increased use of chemicals for friction control. WRM is not predictable, and requires vigilance. Road-owners usually provide operation procedures (Larsen et al., 2011; Vegagerðin, 2012) for winter maintenance operators to follow for specific road conditions including observation, mechanical snow removal, the application of deicer, and gritting as needed during the winter months (NPRA, 2014).

The term "anti-icing" refers to the action of applying chemicals to prevent wet pavements from freezing by lowering the freezing point of the water. Anti-icing also prevents the initial bonding between the pavement and frozen precipitation. De-icing describes the act of using chemicals to remove snow and ice that have already bonded with the pavement. Additionally, chemicals are used for anti-compaction by weakening the bond between the snow crystals to prevent the snow from forming a hard crust and bonding to the pavement surface (Wåhlin and Klein-Paste, 2015), making it easier to remove. Deicers are applied in solid form, pre-wetted, or as solution depending on condition on the road. A study of operators' experiences in North America reports that most winter maintenance operators felt that anti-icing helps to improve roadway safety, achieving bare pavement more efficiently and making mechanical snow removal easier (Cui and Shi, 2015). It is known that chemicals have adverse effects (Fay et al., 2013; Fay and Shi, 2012) and that their use is not always appropriate, as their effectiveness is determined by the temperature and precipitation (Norem, 2009). Additionally, different types of chemicals often have different degrees of effectiveness (Fay and Shi, 2011; Kramberger and Žerovnik, 2008; Wåhlin and Klein-Paste, 2015). Several studies have focused on the effects of anti- and de-icing materials, comparing different types (Fay and Shi, 2015; Fitch et al., 2013; Ramakrishna and Viraraghavan, 2005; Shi et al., 2014b). Others evaluate their total performance by considering the effectiveness of deicer materials in relation to their environmental sustainability (Fitch et al., 2013; Shi et al., 2014a). The method considered most effective is the application of the right amount of the right type of salt for the prevailing temperature, at the right time (Kramberger and Žerovnik, 2008).

Sodium chloride (NaCl) is the most commonly-used material for anti-and de-icing, and has been proven to be most effective in low temperatures (Merrikhpour and Jalali, 2013; Munck et al., 2010; Ramakrishna and Viraraghavan, 2005; Rivett et al., 2016). It is the chemical on which this research focuses, henceforth de-icers refer to NaCl unless otherwise stated. Other commonly used deicers include, for example, calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), calcium magnesium acetate (CMA) and potassium formate (KCOOH) (Klein-Paste and Wåhlin, 2013).

In society today, people expect to be able to travel all year round. The result of this is a continuing increase in the demand for snow removal and in the use of chemicals during winter months. The use of deicer has increased in cold regions during recent decades (F. Li et al., 2015; NPRA, 2017; Prosser et al., 2017). It is expected that all modes of transport will continue to grow by 2050 (EC, 2013). In Norway, personal transport is estimated to increase by 28% by 2050 while goods transport is estimated to increase by 70% for the same period (Samferdselsdepartementet, 2017). Therefore moving towards low- or zero-emission road transport is of utmost importance. WRM is increasingly considered an important part of transportation sustainability (Shi et al., 2013). Contributing to this process, this study addresses the following questions:

1. What is the focus, thematically, of research concerning the environmental impacts and effects of WRM?
2. How do WRM activities influence global environmental impacts and local environmental effects?
3. What are the main research methods used to find the environmental impacts and effects of WRM?

These questions are addressed through a review of available relevant literature on the subject. The scope of this article is limited to the effects of WRM, and therefore the effects of construction and general maintenance are not included.

The objective of this study is to provide a scientific review of the state of knowledge about the environmental impacts and effects of WRM in cold-climate regions; effects pertaining to localized,

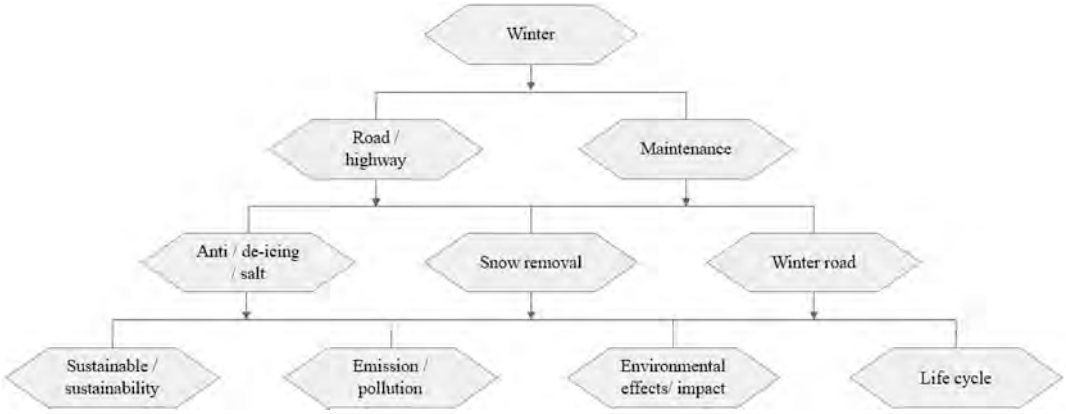

Fig. 1. Search criteria for Scopus.

incremental changes, and impacts relating to systemic changes at a global scale. The focus is on cold-climate regions, which can be defined as regions where snow and ice are present for at least part of the year.

2. Theoretical framework

To get a good representation of the literature pertaining to WRM and the environment, a clear and specific search for relevant scientific articles was vital. The search results then needed further reviewing, limiting and categorization. The following section explains these steps.

2.1. Search terms

For this paper, Scopus (Elsevier B.V., 2018) was used for bibliometric purposes. Two searches were considered relevant for the purposes of this paper. They were both limited to English-language scientific articles and reviews published in 2000–2018. The first search focused on WRM using several key words to try to catch all articles focusing on environmental issues. The search criteria are shown in Fig. 1, where horizontal and vertical keywords are linked by "or" and "and" logic respectively.

The search based on the criteria shown in Fig. 1 returned 74 articles. The second search focused on catching articles on energy and/or fuel consumption during winter road maintenance. This search returned ten articles, of which one had already been included. This volume of 83 articles was considered beyond the scope of this review, besides which not all of the articles met the aim of this study, and therefore further limitation of the articles was needed.

2.2. Article selection for further study

The title, key words and abstracts of the articles found were examined in order to exclude any articles that were not relevant for the purpose of this study. The first step was to exclude articles that did not address environmental impact or effect. Some of the articles addressing environmental issues did not address WRM.

However, articles that addressed energy consumption or efficiency as means of limiting environmental impacts/effects were included. The articles were then categorized according to their focus area and the main theme.

The remaining 35 articles are considered to offer a good representation of the state of knowledge today. A few handbooks and reports as well as selected papers about the execution of WRM were included in the review for background information, to add overall value to the study (Fig. 2).

Through qualitative examination of the titles, key words and abstracts of the selected articles these papers were then arranged according to their focus area and then into the categories shown in

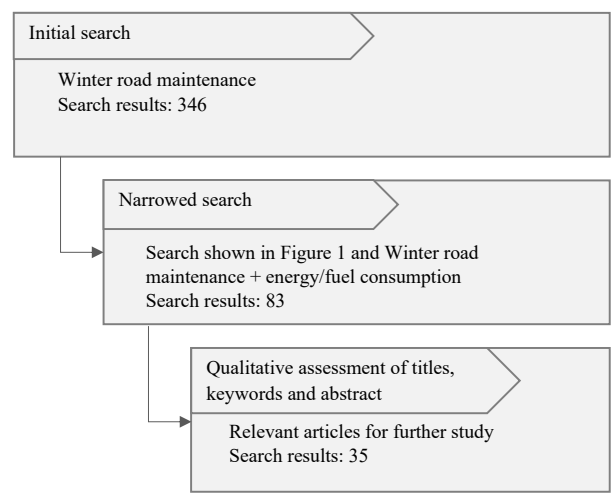

Fig. 2. Search procedure and explanation of how only relevant articles were found. Each step presents the number of articles found.

Table 1
Article focus and category.

Focus	Categories
Local	Soil
Global	Air
Method	Water
	Vegetation
	Biodiversity

Table 1. While the Method category does not always address the impact or effects of WRM, it does reflect on procedures that could be useful for the mitigation of emissions. Finally, some of the articles reviewed fit into more than one category, as most have a main focus but also discuss other effected environmental mediums. The borders between the categories are therefore sometimes crossed.

Additionally, the selected articles reference lists were examined to reveal any highly relevant conference's that might benefit the review. It was found that many of the papers have used technical reports by environmental agencies and road administration (eg. Fitch et al., 2013; Gałuszka et al., 2011; Guesdon et al., 2016; Munck et al., 2010; Nordin and Arvidsson, 2014; Ramakrishna and Viraraghavan, 2005; Rivett et al., 2016). Regarding relevant conferences that could give valuable information, the International Winter Road Congress (PIARC) is the one that was referenced most often, however, it is only referenced in three articles (Arvidsson, 2017; Hääl et al., 2008; Ratkevičius and Laurinavičius, 2017). The International Winter Road Congress has been

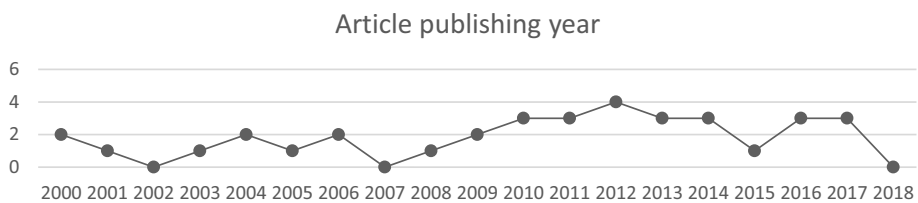

Fig. 3. Number of articles by publication year.

a sharing platform for cold regions countries since 1969 and is held every four years. This did not warrant special search in the conference proceedings for additional information.

3. Results and discussion

The articles reviewed a wide range of topics. This section gives an overview of the results of the literature search and then moves on to the environmental impacts and effects of WRM.

3.1. General overview of search results

Since the year 2000, on average two articles have been published per year on the topic of the environmental load of WRM, as shown in Fig. 3. The figure shows that no articles were published on the subject in 2002 and 2007, and that there is ongoing research with a slight increasing trend, with 66% of the articles reviewed published after 2010.

Looking at the focus of the articles (see Fig. 4) it is clear that *Local effect* has been researched the most, and far less attention has been paid to *Global impact* and *Method*. The local effect on water is the area with the highest number of articles. Only two of the available articles focused particularly on the effect on nearby biodiversity of road salting. Again, the categories often overlap.

It is clear that there has been more research on the local effects of WRM, with an emphasis on the environmental effects on water and soil. Additional specific research on the effects of WRM on biodiversity are necessary.

3.2. Environmental impacts and effects of WRM

The results of the review are presented here to answer the questions above regarding the themes, environmental impacts and effects and methods of the reviewed articles to present state-of-the-art knowledge on the environmental impacts and effects of WRM.

Research has shown that operation and maintenance throughout the lifetime of a road is highly relevant when it comes to emissions. Assuming a lifetime of 100 years and not taking into account emissions from traffic, operation and maintenance can be responsible for up to half of a road's emissions throughout its lifetime. Winter maintenance contributes approximately a third of total road operation and maintenance emissions, which include pavement maintenance and regular maintenance in addition to winter maintenance. This result was obtained through calculations of the documented energy consumption of winter maintenance vehicles and the salt used (Birgisdóttir et al., 2006).

3.2.1. Global impact

The global impacts of WRM include climate change and ozone depletion, with fuel combustion from WRM vehicles as the largest contributor. Fuel consumption is affected by several parameters, such as road alignment in the landscape Booto et al. (2017), road roughness, rolling resistance, speed, wind, tire pressure, driver behavior and eco-driving, as well as the macro- and micro-structure of the road, the age of the vehicle and its engine efficiency. Some of these parameters are strongly influenced by snow and ice, and therefore by WRM operations; such as road roughness and rolling resistance and the likelyhood of traffic congestion. Snow and ice and should therefore be considered when road traffic fuel consumption is estimated. This however is rarely done: the weather conditions taken into account are mainly temperature, humidity and wind (Nordin and Arvidsson, 2014). Moderate traffic congestion has proven to reduce overall emissions from traffic on roads (Avetisyan et al., 2014; Barth and Boriboonsomsin, 2008) due to the vehicles' lower speed and thereby reduced fuel consumption during the congestion. Maintenance operations can cause moderate congestion or even delays, but it has been found that such a delay will generally only cause a small amount of emissions compared to the emissions from the maintenance operation itself. Delays on roads already used to full traffic capacity are found to cause an exponential increase in emissions during road maintenance work, indicating that future traffic levels on roads are very important when estimating road life-cycle emissions (Galatioto et al., 2015).

Lower speeds decrease fuel consumption, and precipitation often causes traffic to slow down. With this in mind it is interesting to look at the energy efficiency of WRM; that is, to look at the overall emissions of both WRM and the traffic on the road compared to the consumed energy of traffic on snow- and ice-covered roads. Anti- and de-icing measures are, according to Nordin and Arvidsson, never energy-effective compared to allowing snow to lie on the road, which reduces traffic speed and thereby energy consumption. This is very interesting in theory, but road safety is also important. Road accidents require energy for the rescue and clean-up, as well as for the heavy road congestion they may cause.

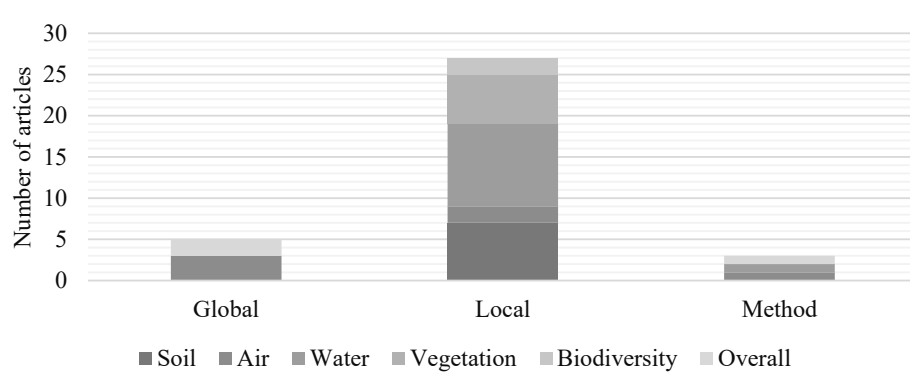

Fig. 4. Number of articles by category and focus area.

Nordin and Arvidsson (2014) found that the speed limit on a road strongly affects when it is energy-effective to remove snow from it. To elaborate on this, by including energy used by both general traffic and WRM vehicles it is possible to see when it is energy-effective to remove the snow from the road. As small amounts of snow on the road reduces the speed of the general traffic it will use less energy than if they maintain the speed and WRM vehicles additionally use energy for clearing the roads. At a speed limit of 90 km/h the snow cover should be more than 1 cm (at low density 100 kg/m3), while a higher speed limit of 120 km/h requires snow removal when the snow reaches 2.5 cm (also low density snow). This changes slightly if the snow is wet, when it is energy-effective to remove it when it is only 0.5 cm thick. This suggests that the timing of winter maintenance operations is highly relevant.

However, a study of road conditions and WRM in 2016 (Min et al., 2016) found that better road conditions reduce emissions. The logic being that adverse weather increases speed variability and that drivers strive to maintain their speed, whereby the fuel consumption of the vehicle is bound to increase with the increased resistance and the need to switch to higher gears to maintain speed. This reduces fuel combustion efficiency, leading to increased fuel consumption (Laurinavicius et al., 2010; Min et al., 2016).

The above studies highlight the role of the driver in energy consumption. They agree that WRM effects energy consumption, but do not agree when it is beneficial to conduct WRM, with respect to energy consumption. One of the reasons for this can lie in a very basic assumption about driver behavior. Nordin and Arvidsson's (2014) model assumes that drivers adjust their speed up to a point according to the weather and road conditions, and is based on traffic flow monitoring in Sweden. Min et al. (2016) on the other hand assume that drivers strive to maintain their speed, that is, they agree that overall speed is reduced but find that speed variability increases. These modeling techniques result in significant differences in the results, as lowering the speed of the vehicle reduces energy consumption while striving to maintain speed increases it.

3.2.2. Local effect

Local environmental effects of WRM include reduced air quality and changes and/or harm to vegetation, soil and watersheds (Mattias Bäckström et al., 2004; Green et al., 2008; Norrström and Bergstedt, 2001). The main pollutants include nitrogen oxides (NOx), sulfur oxides (SOx), non-methane hydrocarbons, particulate matter (PM2.5 and PM10), carbon monoxide (CO) and volatile organic compounds (VOCs) (Zhang et al., 2010b). The local effects of winter maintenance are mainly caused by salting and by exhaust gas, which along with tire and road wear contribute to the emission of particulate matter. In the light of this it is not surprising that the main theme of the reviewed articles was the local environmental effects of deicers. The effects of using deicers are very location-specific because of differences in the distribution method, type of salt used, road drainage systems, distance to nearby streams and watersheds, topography, temperature, precipitation, wind and absorption to nearby soil, as well as storage facilities for the deicers (Ramakrishna and Viraraghavan, 2005).

3.2.2.1. Air. Local environmental effect on air include noise and reduced air quality, both of which affect human health (Colvile et al., 2001) for example aggravate asthma, reduce lung functions and cause eye irritation. Local effects on the air from traffic in general are mainly caused by the emission of solids in the form of particulate matter ($PM_{2.5}$ or PM_{10}, where the number refers to the size of the particles in μm) and nitrogen oxide (NOx) emissions which affect human health through inhalation (Colvile et al., 2001; Hääl et al., 2008). NOx not only contributes towards higher levels of PM but additionally towards smog formation and acid rain. Fuel combustion in diesel engines is the main source of Nitrogen oxide (NOx) emissions (Chen et al., 2012) which cold weather further increases (Min et al., 2016). The use of studded snow tyres on bare[1] roads additionally causes micro-destruction of the pavement where the material is made airborne, along with salt and sand. Especially within cities, where WRM is also often high, this is a real problem because increased of PM levels affect human health. However, it should be noted that depending on the landscape around a city, the main contributor to PM levels may be domestic wood combustion together with diesel engine exhaust, rather road dust and deicer. This was found to be the case in a mountain valley in the US, where wind and thermal circulation are crucial in retaining acceptable levels of air pollutants (Chen et al., 2012).

For highways on the other hand, sand and deicer have been found to be significant contributors to PM levels during winter (Gertler et al., 2006). Again, the topography, weather and urban density play a substantial part in both what pollutants are released and pollution levels. Estimations suggest that after a weather event, where deicer has been applied the level of PM is likely to increase by approximately 30%. immediately afterward. However, the increase in PM is almost double that of the control: the first dry day after a weather event (ibid). In the area referred to here not only a liquid deicer but also sand were applied. Studies have shown that the effects of PM decreased to background levels within 50 m of the road (M. Bäckström et al., 2003).

Noise is also a local effect, with an increase of 5 dBA significantly affecting human health. Noise pollution from studded snow tires in both urban and rural areas is quite high. It is estimated that reducing the use of studded tires by 20% would decrease noise emissions by 1–1.5 dBA (Laurinavicius et al., 2010), and such a reduction is considered significant for human health.

Air pollution from WRM is therefore considerable, and some efforts have been made to limit the effects. Street sweeping to reduce road dust and PM levels in the long run is one of these measures: according to Gertler et al. (2006) it is not clear whether this is beneficial. In the short term it only re-suspends particles in the air, causing higher PM levels. However, there have been developments that aim at reducing the necessity of deicer and other abrasives by using sweeps to achieve bare, dry road sooner after weather event, as discussed in section 3.4.

3.2.2.2. Soil. Local environmental effects of WRM on soil include damage to organisms, the mobilization of metals, and increased salinity (Hääl et al., 2008; Löfgren, 2001; Ramakrishna and Viraraghavan, 2005; Sun et al., 2015). The effects on soil are generally limited to within about 10 m from the road (Hääl et al., 2008), with a significant drop in concentration at 2 m from the road (Pedersen et al., 2000), but they can be detected at up to 50 m (Löfgren, 2001), with high seasonal variability. The environmental effects of WRM on soil are mostly from the use of deicer, which has been proven to affect soil alkalinity. Soil samples taken near a high-trafficked road show that the average pH of roadside soil is considerably higher (7.36) than the optimal pH for plant growth, of 4.5–6.5 (Czerniawska-Kusza et al., 2004; Hääl et al., 2008). This is supported by Gałuszka et al. (2011), who found that snow near the city of Kielce (south-central Poland) had a mean pH of 7.3 and soil 7.8. Additionally, zinc is sensitive to pH in the soil and an increased amount of chlorides results in increased concentration of zinc (Hääl et al., 2008). The mobilization of heavy metals is effected by WRM, as deicer increase their solubility.

Furthermore, an increase in ionic strength has the ability to displace other important cations (Al^{3+}, Ca^{2+}, Mg^{2+} and H^{+}) which can negatively affect soil chemistry (Czerniawska-Kusza et al., 2004; Löfgren, 2001). In the presence of salt these have been found to increase in concentration by 18–51 times normal levels. The ions Na^{+} and K^{+} also increase, less drastically, to 2–6 times more than normal (Löfgren, 2001).

Heavy metals from road traffic tend to accumulate in nearby soil and can later be mobilized by de-icers and enter freshwater ecosystems

[1] Bare road is when a road is snow and ice free and dry.

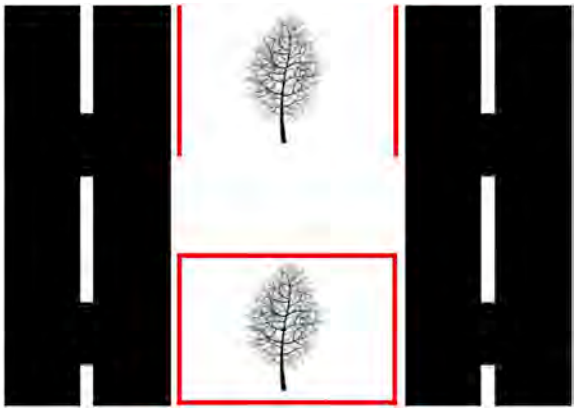

Fig. 5. Straw mats protective measures, parallel to the road and square around the tree.

(Schuler and Relyea, 2018). The application of deicer along with the intrusion of salt water into freshwater aquifers due to a higher sea level are likely to increase the mobilization of lead (Pb), mercury (Hg) and arsenic (As) from both the soil and coastal aquifers into the nearby freshwater aquifers. Such mobilization is dependent on several factors such as the type and form of the deicer used, the heavy metal involved, redox process (process of reductant transferring electrons to the oxidant), and the presence and types of other ions, as well as organic matter content in the medium (Sun et al., 2015). The effect of heavy metal mobilization range from toxicity to organisms to harm to freshwater habitats and intrusion to groundwater systems used for both human consumption and agriculture (Schuler and Relyea, 2018).

Sun et al. (2015) found that when deicer, salt and an additional mix of $CaCl_2$ (seawater) were introduced to a water medium, the elements investigated in the study above had higher mobility than when only deicer was used. Na, K, Ca, Mg, Al, Fe, Mn, Zn, Cu, Pb, As, Hg, Si, Cl, S, and P were all found to peak in concentration in soil in sync with peak concentrations of Ca and Na in water. This agrees with Bäckström et al. (2004) results for Cd, Cu, Pb, and Zn. Additionally, they (ibid) point out that other trace elements are also mobilized by deicer.

A couple of studies that focused on the effects of deicer on soil found that the effects were temporary and were not sufficient to suggest that any drastic changes should be made (Hääl et al., 2008; Ramakrishna and Viraraghavan, 2005). However, they also found that as snow melted by the end of winter the concentration of calcium and chloride gradually increased in the soil, with high variation depending on the level of WRM service. A study conducted in Denmark found that the soil did not leach much salt during the spring and concentration of salt in the soil increased during the summer with the decreasing amount water in the soil. It was not until fall that most of the salt leached out. This means that during plants' growth period soil water has the highest concentration of salt compared to other seasons (Pedersen et al., 2000).

Road dust, which originates from the wear and tear of the road and of vehicle parts such as tires, brakes, and engine parts, also affects the soil. Road dust is a source of heavy metals, including but not limited to copper, chrome, zinc and nickel. Deicers are also partly to blame here, as they cause the corrosion of vehicle parts which is then transported to nearby soil (Hääl et al., 2008).

WRM can also have other consequences through its effects on soil. WRM-affected soil has negative effects on construction materials, specifically galvanized steel reinforcements. Deicer used near concrete structures should be sulphate-free, as sulphates in the soil have been shown to significantly increase concrete corrosion (Padilla et al., 2013).

3.2.2.3. Vegetation. Local environmental effects of WRM on vegetation include, among others, reduced biomass, a disorder in photosynthesis due to a decreased chlorophyll level and cell plasmolysis. Deicers also reduce the bioavailability of important nutrients by alkalizing the soil. This can lead to the total destruction of the plant or tree (Czerniawska-Kusza et al., 2004; Dmuchowski et al., 2011; Gałuszka et al., 2011; Munck et al., 2010; Viskari and Kärenlampi, 2000). The environmental effects of WRM on vegetation are caused mostly by deicer but also by exhaust fumes. The trend over the last two decades indicates a significant correlation between forest mortality and the use of deicer on nearby roads (Fan et al., 2014). For an indication of the forest mortality rate, it can be assumed that increasing deicer used by 10 tons/km could lead to increased odds of mortality of nearby vegetation by 10% when precipitation is high. Lower mortality can be assumed in years with lower precipitation and the same increase in the use of deicers (ibid).

The accumulation of salt in the needles of pine trees has been found to directly correlate with the amount of deicer used on nearby roads (Viskari et al., 2000). A similar process has been observed in trees with leaves, in which the salt accumulates and cause toxicity; the salt in leaves also makes the tree more vulnerable to frost (Dmuchowski et al., 2011; Munck et al., 2010).

To protect trees in a central strip from the effects of salt, straw mats were laid around the tree trunk. This did not give any significant protection against either salt spray or salt water in the soil around the tree. However, when the protection mats were in a square, as shown in red in Fig. 5, they gave considerable protection. This square configuration was found to give the greatest protection as they reduced direct sprey of salt to soil and tree from the road while still providing protection all around the tree. The optimal solution is to plant trees at least 2 m from the road, as salt deposition at this distance decreases by 50–80% (Pedersen et al., 2000). This is in line with Fan et al.'s (2014) findings of greater forest mortality within the first 10 m from the road compared to the mean of the first 100 m from the road. Distance from the road beyond 20 m was found to be insignificant. This is supported by both Munck et al. (2010) and Viskari et al. (2000). Viskari et al. (2000) found that the concentration of sodium and chloride in pine needles were equivalent to the background level at a distance of 20 m. The topography around the road is also important. While no difference was found between upslope and downslope mortality rates, interestingly but not surprisingly forest on a sharper slope was more sensitive to salt (Fan et al., 2014). This is useful knowledge when planning roads in areas with a need for extensive WRM, where benefits could be achieved for nearby vegetation.

The articles reviewed are in consensus about the usefulness of trees and other vegetation as a barrier for salt spray from the road. Avoiding aerial spray of deicer is very important to prevent further effects on vegetation, as it has been found to have a greater effect on the accumulation of salt than root uptake (Fan et al., 2014; Munck et al., 2010; Pedersen et al., 2000; Viskari and Kärenlampi, 2000). Weather and topography are also often mentioned as local variations that can influence the degree of effect deicer on vegetation (Meriano et al., 2009; Munck et al., 2010; Viskari et al., 2000). Finally, the type of vegetation is important, with tree species and density having a significant effect on the probability of deicer damage (Munck et al., 2010). A study conducted after overuse of deicer in Beijing found that bushes are more vulnerable than trees with leaves, which again are more vulnerable to large amounts of salt than trees with needles (Z. Li et al., 2014). This can be explained by the variation in the surface area of the plants and the proportion of it receiving the spray.

3.2.2.4. Water. Local environmental effects on water are mainly eutrophication, higher pH values, and smaller amounts of oxygen dissolved by typical water pollutants such as ammonia, nitrates and phosphates. This affects organisms in the water by changing the necessary condition for living (Aghazadeh et al., 2012; M. Bäckström et al., 2003; Merrikhpour et al., 2013; Ostendorf et al., 2009; Ramakrishna and Viraraghavan, 2005). Zhang et al. (2010a, 2010b) investigated the life cycle emissions of pavement overlay system. They

found that the production of materials used are high emitters of pollutants contributing to the largest share of both phosphate emissions and dissolved matter, while the influence of on-road traffic is responsible for the majority of biochemical oxygen demand (BOD) emissions (Zhang et al., 2010a). Furthermore, emissions of nitrogen oxides (NOx) are primarily from fuel combustion. NOx is the main contributer towards eutrophication in surface water through formation of nitrates (Schlegel et al., 2016).

The effects on soil and vegetation discussed above are closely linked to affected surface and groundwater. WRM's effects on water are mostly caused by the use of deicer as well as by the de-icing vehicles' exhaust gas and wear on the road. Among the possible effects are increased salinity up to toxic levels, eutrophication, increased bioavailability of toxic substances, and high levels of lead (Merrikhpour and Jalali, 2013). There are indications that the higher lead levels near highly trafficked roads are not due to the use of deicer but to fuel combustion. However, chemicals and ions in runoff generally do increase in the presence of deicer (M. Bäckström et al., 2003; Ostendorf et al., 2009). Bäckström et al. (2003) found that copper (Cu), cadmium (Cd), cobalt (Co), lead (Pb), tungsten (W) and zinc (Zn) all increased during the winter. Deicer can also affect groundwater and drinking water, and thereby human health. The concentration of chloride in surface water and groundwater has been increasing over recent decades along with increasing use of road salt in cold climates (Kramberger and Žerovnik, 2008; Meriano et al., 2009; Novotny et al., 2008; Ostendorf et al., 2009; Prosser et al., 2017). Sodium does not have the same effect, probably because Na ions are more likely to be retained in soil (Guesdon et al., 2016).

The contamination of groundwater by deicer is a slow process (Aghazadeh et al., 2012), but it is a matter for concern as groundwater does not have the same ability as surface water to dilute the salt, as the water flow rate and volume are less than those of surface water (Ramakrishna and Viraraghavan, 2005). Furthermore, chronic use of deicer can increase heavy metal concentration in groundwater and catchments. Catchments generally seem to have the ability to remove 35–50% of deicer chemicals by overland flow, while the rest accumulate until they reach steady-state concentrations (Meriano et al., 2009).

The effect of increased chloride concentration on surface water can include a change in the density gradient, salt-induced stratification and the stimulation of algae growth. Ramakrishna and Viraraghavan (Ramakrishna and Viraraghavan, 2005) conclude that the impact of the use of deicer on surface water was negligible due to the low concentrations and volumes of water, which agrees with what Novotny et al. found. They (ibid) found that even though the lakes investigated were affected by nearby use of deicer it was still not enough to prevent full mixing[2] during the year. Seasonal changes in salinity have also been observed in lakes near to roads, where concentration increases through the winter months and often peaks slightly after the last application (Allert et al., 2012; Novotny et al., 2008). As road deicer use is likely to increase, its effects should be regularly re-evaluated.

As with soil, water affected by deicer is slightly more alkaline (pH 7.5–7.9) than background water and a higher level of contamination is observed in the presence of deicer (Aghazadeh et al., 2012; M. Bäckström et al., 2003; Merrikhpour et al., 2013).

In a recent paper Prosser et al. (2017) report that it is likely that salt is a driver for toxicity in road run-off. This only emphasizes the need for carefully-conducted winter maintenance operations, especially with the use of deicer. The effect of deicer on surface and groundwater depend, like the other medians, on many factors which include but are not limited to application rate and frequency, the distance between the median and the road, and the flow of water in the catchment. Heavy precipitation causes rapid salt runoff and dilution (Aghazadeh et al., 2012; Rivett et al., 2016). Other WRM measures can also affect water in urban areas where traffic is heavy. A study of the correlation between deicer and contamination in road runoff (Helmreich et al., 2010) concludes that the link between contamination levels and deicer used on highly trafficked urban roads was weaker than the contamination caused by the application of gravel.

3.2.2.5. Biodiversity. Local environmental effects of WRM on biodiversity include physical abnormalities, reproductive issues, and a higher mortality rate (Allert et al., 2012). The searched used for this literature review returned few articles that addressed the effect of salt on biodiversity and wildlife. This is an area that needs more attention, as the studies reviewed here point out (Hintz and Relyea, 2017; Sanzo and Hecnar, 2006; Jones et al., 2016). The effect of long-term exposure to a high concentration of deicer include for example physical abnormalities (growths and defects), reproductive issues, and an increased mortality rate; it can also cause a change in wetland foodwebs and the structure of ecological communities eg. species hierarchy, interaction such as competitions and parasitism (Allert et al., 2012; Jones et al., 2016).

Wildlife is mainly affected by water in runoff, streams and lakes, with streams often containing the highest concentration. Streams are not only affected during the winter or when snow melts in the spring but can also have high concentrations throughout the year. This stresses their ecosystem. According to Hintz and Relyea (2017), salmonids are sensitive to deicer, as are top predators, which play a vital role in maintaining the ecosystem in the stream. A high concentration of deicer of more than 3000 mg Cl^{-} L^{-1} causes problems for egg survival in Atlantic salmon and can also create oxidative stress and affect metabolism, renal function and the development of salmonid embryos (ibid).

Similar effects of deicer were seen in larval wood frogs, where even lower concentrations were found to be lethal in acute experiments. Furthermore, both behavioral and physical symptoms presented at all salt concentration levels, including reduced feeding and swimming activity and a slower response to stimuli. Chronic experiments found similar behavioral and physical symptoms within the first week (Sanzo et al., 2006).

The results suggest that salt has a negative impact on local ecosystems. Different species have different tolerance for salt, which may lead to an altered species composition and affects interspecies competition. This may lead to local extinction of species. The effect of deicer on wildlife therefore calls for further research and efforts to reduce the use of deicer.

3.3. Research methods

Returning to the research questions, the main focus of research on the global environmental impacts of WRM activities is on climate change. As climate change is strongly affected by energy consumption, the method of investigating the impact of WRM uses fuel consumption models along with weather models and monitoring, traffic density and road-surface conditions, to establish bases for the models. The main strength of this method is that it is very detailed and captures the largest single source of emissions. While this is a powerful method for studying global environmental impact, it cannot provide sufficient information on local environmental effects. The models capture PM emissions directly from the use of fossil fuels, but omit dust from the road, vehicles and tires.

Where local environmental effects are concerned, the main research area has been water, followed closely by soil. Local effects are strongly linked to the application of deicer, which is the focus of most of the articles reviewed. The main methods used to measure local environmental effects are on-site sampling and the monitoring of air, water and soil. The method for vegetation additionally includes macroscopic observation of both death and damage. The research methods used for

[2] Full mixing of lakes is when the different density water layer mix fully so that oxygen and nutrients are distributed throughout the lake (Kirillin and Shatwell, 2016).

effects on biodiversity include both site sampling and laboratory testing. Chronic and acute tests were performed to obtain the results reported in these articles. The studies varied when it came to the dosage tested, with some using field data while others used several environmentally-relevant laboratory doses tests to find the effect of deicer. The methods applied in the studies are considered well-suited to the purpose even though the observational results of the effects on vegetation is difficult to verify. The studies and their methods are well recognized as fit for their purpose and could, if used combined, compliment results for global environmental impacts.

However, an overall view could further enhance understanding of the impacts and effects of WRM on the environment. Fitch et al. (2013) and Birgisdóttir et al. (2006) present the only studies to use life cycle assessment (LCA). LCA is often used to analyze emissions from a single product or service but has also been used for larger projects and systems (Stripple, 2001). Butt et al. (2015) advocate using LCA on road infrastructure and projects to help to improve technology towards more sustainable roads in the future. They believe that LCA can be especially useful for making decisions at both network and project levels. To be able to make the right choices when it comes to emission reduction it is important to use tools that are capable of quantifying current emissions on both a global and a local scale, comparing the effects of different policies and technologies, handling scenario analysis and considering several different types of emissions to avoid problem-shifting. The LCA framework has been used for this purpose (Baitz et al., 2013; ISO, 2006). Using it to evaluate procedures and materials for WRM could therefore help to reduce emissions from road operations and maintenance over a roads' life-cycle.

3.4. WRM methods and alternatives to deicers

Many of the studies reviewed for this article conclude that due to the effects of deicer, mainly on water, soil and vegetation, new strategies for WRM should be developed and followed (eg. Fan et al., 2014). The literature has a lot to offer regarding the most effective de-icing materials as well as operational procedures to reduce the amount of deicer used and its dispersion towards the roadside (eg. Koefod et al., 2015; Lysbakken and Norem, 2011). However, de-icer is not the only option for keeping roads dry, safe and open. In periods of extreme cold, applying deicer is ineffective and does not increase friction on the road. Therefore the use of salt in such extreme weather conditions is not advised. For such situations more adapted solutions are necessary. Efforts are being made to achieve dry, bare roads faster using brushing. This idea was tested a few years ago and it was found that during a snowstorm the road had to be brushed approximately every 30 min, which is resource-intensive and unrealistic (NPRA, 2014; Sivertsen, 2015). However, this solution has been developed and is in use at airports. The method is starting to be used on winter roads, where the aim is reduce the need for salt (Øveråsen AS, 2017). Using brushes at the end of rather than during a weather event is having positive results. The environmental benefits of this solution have not yet been investigated, but it offers an interesting possibility for reducing not only the use of deicer but also the total distance driven to apply such chemicals. It is strongly recommended to further investigate the effects of de-icer use and their fate in the environment. Furthermore, methods that drastically reduce or eliminate the necessity for de-icers should be prioritized.

The effects of deicer can be offset slightly if the effects of studded tires are also taken into account. Wear on a wet surface is estimated to be 2–6 times higher than on a dry surface, and adding the effect of studded tires in winter creates such high wear that beside it, summer wear appears almost negligible (M. Bäckström et al., 2003). The use of studded tires during the winter season increases vehicles' fuel consumption and wear on the road pavement, causing increased emissions of, for example, particulate matter (Hallberg and Renman, 2006; Laurinavicius et al., 2010). With the extensive winter maintenance carried out today, clearing both snow and ice frequently and applying deicer, it is possible that studded tires could be avoided, thereby preventing the added emissions that they generate. Several countries have banned and/or limited their use (BlackCircles.com, 2018; Elvik and Kaminska, 2011; Laurinavicius et al., 2010). However, a project conducted in Norway has found that accidents increase by 2% in cities that have significantly reduced the use of studded tires (Elvik and Kaminska, 2011).

Several studies have investigated the effectiveness of available deicers (Fay and Shi, 2015; Fitch et al., 2013; Hossain et al., 2014; Ramakrishna and Viraraghavan, 2005; Shi et al., 2014b) and information from these studies could be utilized for a more sustainable use of deicers. This can be achieved by applying the right kind of deicer to the road at the right time. Many articles published since 2000 have addressed road salting methods in search of a way that is both effective and minimizes environmental impact. The effectiveness and appropriate use of deicer are well-documented (Blomqvist et al., 2011; Burtwell, 2001; Klein-Paste and Wåhlin, 2013; Wåhlin et al., 2014), and tools and models have been developed that predict the need for it (Hinkka et al., 2016; Kramberger and Žerovnik, 2008). The problem however seems to be that WRM operators do not know about or choose to not follow recommendations (Raukola and Terhelä, 2001). In an effort to resolve this, WRM agencies have increasingly been requiring operators to attend a course on best practice in winter maintenance as well as offering continued learning on the subject (Gryteselv et al., 2013; Skills Training Centre Ltd., 2014).

Alternative materials to the basic sodium, calcium and magnesium chlorides (NaCl, $CaCl_2$, $MaCl_2$) that make up deicer have been suggested over the years. While their effectiveness and environmental effects are beyond the scope of this article, mentioning some of the alternatives is considered beneficial: they include but are not limited to sugar, levulinic acid ($C_5H_8O_3$) and potassium formate (Fay and Shi, 2012; Ružinskas et al., 2016).

4. Conclusion

This article set out to answer three research questions about the environmental impacts and local effects or winter road maintenance in cold climates, and to this end has closely examined 35 articles considered to give a clear indication of this in order to obtain a good representation of the state of knowledge on the subject. Below are the main conclusions regarding each of the research questions.

1. *What is the research focus, thematically, of research concerning the environmental impacts and effects of WRM in cold climates?*

The papers reviewed show that the research focus is on local environmental effects, with most interest in the use of deicer. It is also clear that the effect on water is the environmental factor receiving the most attention, followed closely by that on soil. Regarding the much less-studied global environmental impacts, the research is almost exclusively on climate change caused mainly by direct emissions from WRM fuel combustion.

2. *How do WRM activities influence global environmental impacts and local environmental effects?*

The main global environmental impacts of WRM are climate change and ozone depletion, both largely from the use of fossil fuel during WRM. Local environmental effects are listed below, along with the main contributors.

Soil: Considerable effect on soil pH, with mobilization of chemicals in the soil, caused by deicer use and some road dust.

Water: Increased salinity up to toxic levels, eutrophication, increased bioavailability of toxic substances and contamination of ground water. The main culprit is deicer, with road dust again contributing.

Air: Effects on PM levels during and after de-icing operations

especially, caused by the road dust in general; the use of studded tires contributes considerably.

Vegetation: Damage to and toxicity of plants from the use of deicer on roads.

Biodiversity: Toxicity causing defects, reduced response time and even death, mainly due to the use of deicer.

3. *What are the main research methods used to find the environmental impacts and effects of WRM?*

The methods used to investigate the global environmental impacts of WRM are predominantly fuel consumption models, with sampling and laboratory testing the main method for local effects. Very few studies use LCA of the WRM as a service, which is considered a beneficial method to use to avoid problem shifting. Further work should include a full LCA of WRM so that it can be included in road LCA in the future and thereby accounting for all aspects of road transportation.

This review emphasizes the need to further investigate the need and use of de-icers as well as optimization techniques for drastic reduction in their use. It is also clear that it is important to incorporate all aspects of road transportation, from the design of the road infrastructure to its construction, maintenance and use, on the path towards zero-emission road transportation.

Author contributions

Hrefna Run Vignisdottir initiated and carried out the main bulk of the research. She was responsible for the literature review and data analysis and was also the main person responsible for drafting the article. Rolf André Bohne and Helge Brattebø served as the main supervisors during the process and, with Babak Ebrahimi, Gaylord Kabongoo Booto, Reyn O'born and Holger Wallbaum, contributed to the analysis and interpretation of the results. Helge Brattebø additionally assisted with the structure of the paper. All the co-authors provided critical comments on the manuscript prepared by Hrefna Run Vignisdottir during the process, and have all given their final approval for this version to be published.

Declarations of interest

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World Scientists' Warning of a Climate Emergency

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, PHOEBE BARNARD, WILLIAM R. MOOMAW, AND 11,258 SCIENTIST SIGNATORIES FROM 153 COUNTRIES (LIST IN SUPPLEMENTAL FILE S1)

Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to "tell it like it is." On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.

Exactly 40 years ago, scientists from 50 nations met at the First World Climate Conference (in Geneva 1979) and agreed that alarming trends for climate change made it urgently necessary to act. Since then, similar alarms have been made through the 1992 Rio Summit, the 1997 Kyoto Protocol, and the 2015 Paris Agreement, as well as scores of other global assemblies and scientists' explicit warnings of insufficient progress (Ripple et al. 2017). Yet greenhouse gas (GHG) emissions are still rapidly rising, with increasingly damaging effects on the Earth's climate. An immense increase of scale in endeavors to conserve our biosphere is needed to avoid untold suffering due to the climate crisis (IPCC 2018).

Most public discussions on climate change are based on global surface temperature only, an inadequate measure to capture the breadth of human activities and the real dangers stemming from a warming planet (Briggs et al. 2015). Policymakers and the public now urgently need access to a set of indicators that convey the effects of human activities on GHG emissions and the consequent impacts on climate, our environment, and society. Building on prior work (see supplemental file S2), we present a suite of graphical vital signs of climate change over the last 40 years for human activities that can affect GHG emissions and change the climate (figure 1), as well as actual climatic impacts (figure 2). We use only relevant data sets that are clear, understandable, systematically collected for at least the last 5 years, and updated at least annually.

The climate crisis is closely linked to excessive consumption of the wealthy lifestyle. The most affluent countries are mainly responsible for the historical GHG emissions and generally have the greatest per capita emissions (table S1). In the present article, we show general patterns, mostly at the global scale, because there are many climate efforts that involve individual regions and countries. Our vital signs are designed to be useful to the public, policymakers, the business community, and those working to implement the Paris climate agreement, the United Nations' Sustainable Development Goals, and the Aichi Biodiversity Targets.

Profoundly troubling signs from human activities include sustained increases in both human and ruminant livestock populations, per capita meat production, world gross domestic product, global tree cover loss, fossil fuel consumption, the number of air passengers carried, carbon dioxide (CO_2) emissions, and per capita CO_2 emissions since 2000 (figure 1, supplemental file S2). Encouraging signs include decreases in global fertility (birth) rates (figure 1b), decelerated forest loss in the Brazilian Amazon (figure 1g), increases in the consumption of solar and wind power (figure 1h), institutional fossil fuel divestment of more than US$7 trillion (figure 1j), and the proportion of GHG emissions covered by carbon pricing (figure 1m). However, the decline in human fertility rates has substantially slowed during the last 20 years (figure 1b), and the pace of forest loss in Brazil's Amazon has now started to increase again (figure 1g). Consumption of solar and wind energy has increased 373% per decade, but in 2018, it was still 28 times smaller than fossil fuel consumption (combined gas, coal, oil; figure 1h). As of 2018, approximately 14.0% of global GHG emissions were covered by carbon pricing (figure 1m), but the global emissions-weighted average price per tonne of carbon dioxide was only around US$15.25 (figure 1n). A much higher carbon fee price is needed (IPCC 2018, section 2.5.2.1). Annual fossil fuel subsidies to energy companies have been fluctuating, and because of a recent spike, they were greater than US$400 billion in 2018 (figure 1o).

Especially disturbing are concurrent trends in the vital signs of climatic impacts (figure 2, supplemental file S2). Three abundant atmospheric GHGs (CO_2, methane, and nitrous oxide) continue to increase (see figure S1 for ominous 2019 spike in CO_2), as does global surface temperature (figure 2a–2d). Globally, ice has been rapidly disappearing, evidenced by declining trends in minimum summer Arctic sea ice, Greenland and Antarctic ice sheets, and glacier thickness worldwide (figure 2e–2h). Ocean heat content, ocean acidity, sea level, area burned in the United States, and extreme weather and associated damage costs have all been trending upward (figure 2i–2n). Climate change is predicted to greatly affect marine, freshwater, and terrestrial life, from plankton and corals to fishes and forests (IPCC 2018, 2019). These issues highlight the urgent need for action.

Despite 40 years of global climate negotiations, with few exceptions, we have generally conducted business

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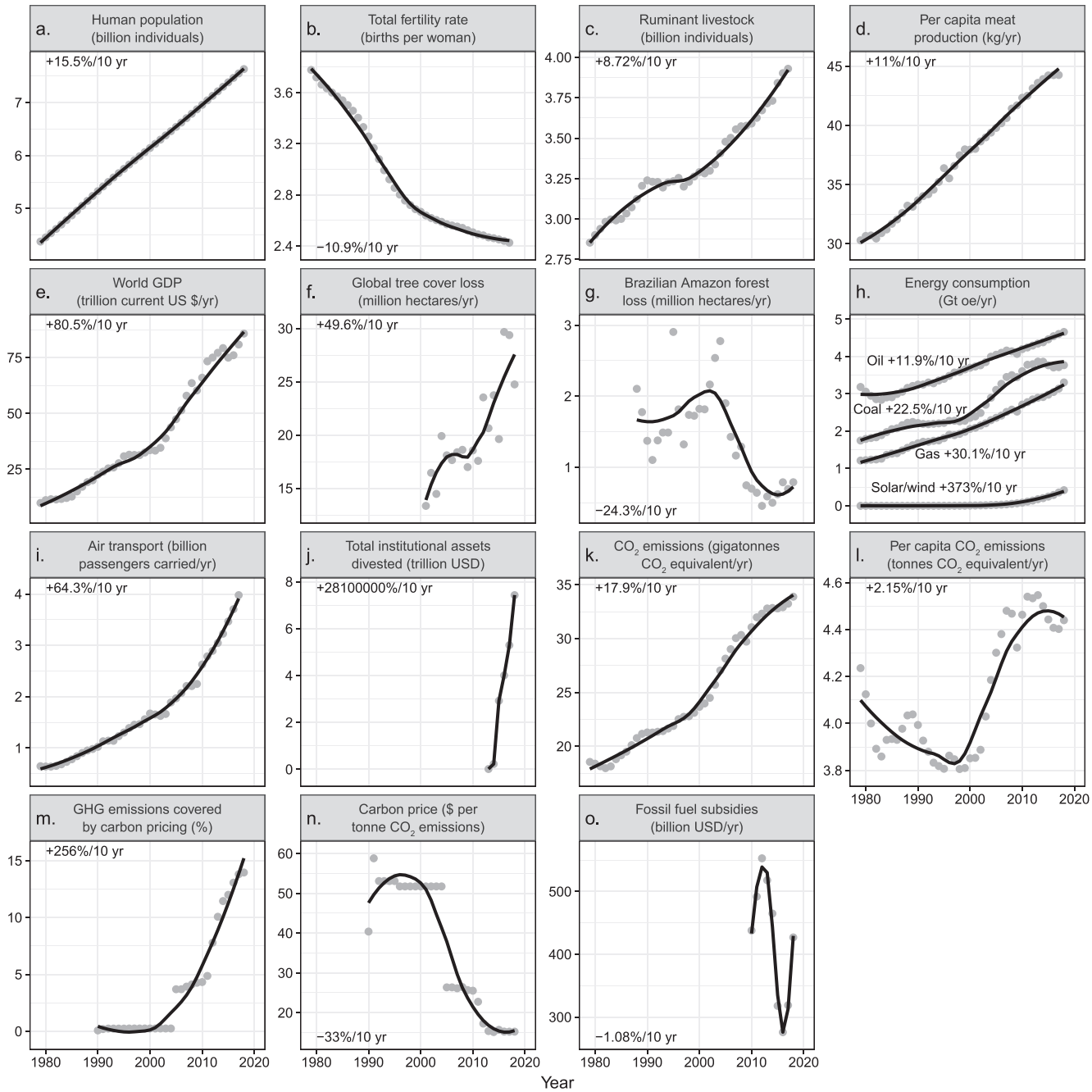

Figure 1. ***Change in global human activities from 1979 to the present. These indicators are linked at least in part to climate change. In panel (f), annual tree cover loss may be for any reason (e.g., wildfire, harvest within tree plantations, or conversion of forests to agricultural land). Forest gain is not involved in the calculation of tree cover loss. In panel (h), hydroelectricity and nuclear energy are shown in figure S2. The rates shown in panels are the percentage changes per decade across the entire range of the time series. The annual data are shown using gray points. The black lines are local regression smooth trend lines. Abbreviation: Gt oe per year, gigatonnes of oil equivalent per year. Sources and additional details about each variable are provided in supplemental file S2, including table S2.***

as usual and have largely failed to address this predicament (figure 1). The climate crisis has arrived and is accelerating faster than most scientists expected (figure 2, IPCC 2018). It is more severe than anticipated, threatening natural ecosystems and the fate of humanity (IPCC 2019). Especially worrisome are potential irreversible climate tipping points and nature's reinforcing feedbacks (atmospheric, marine, and terrestrial) that could lead to a catastrophic "hothouse Earth," well beyond the control of humans (Steffen et al. 2018). These climate

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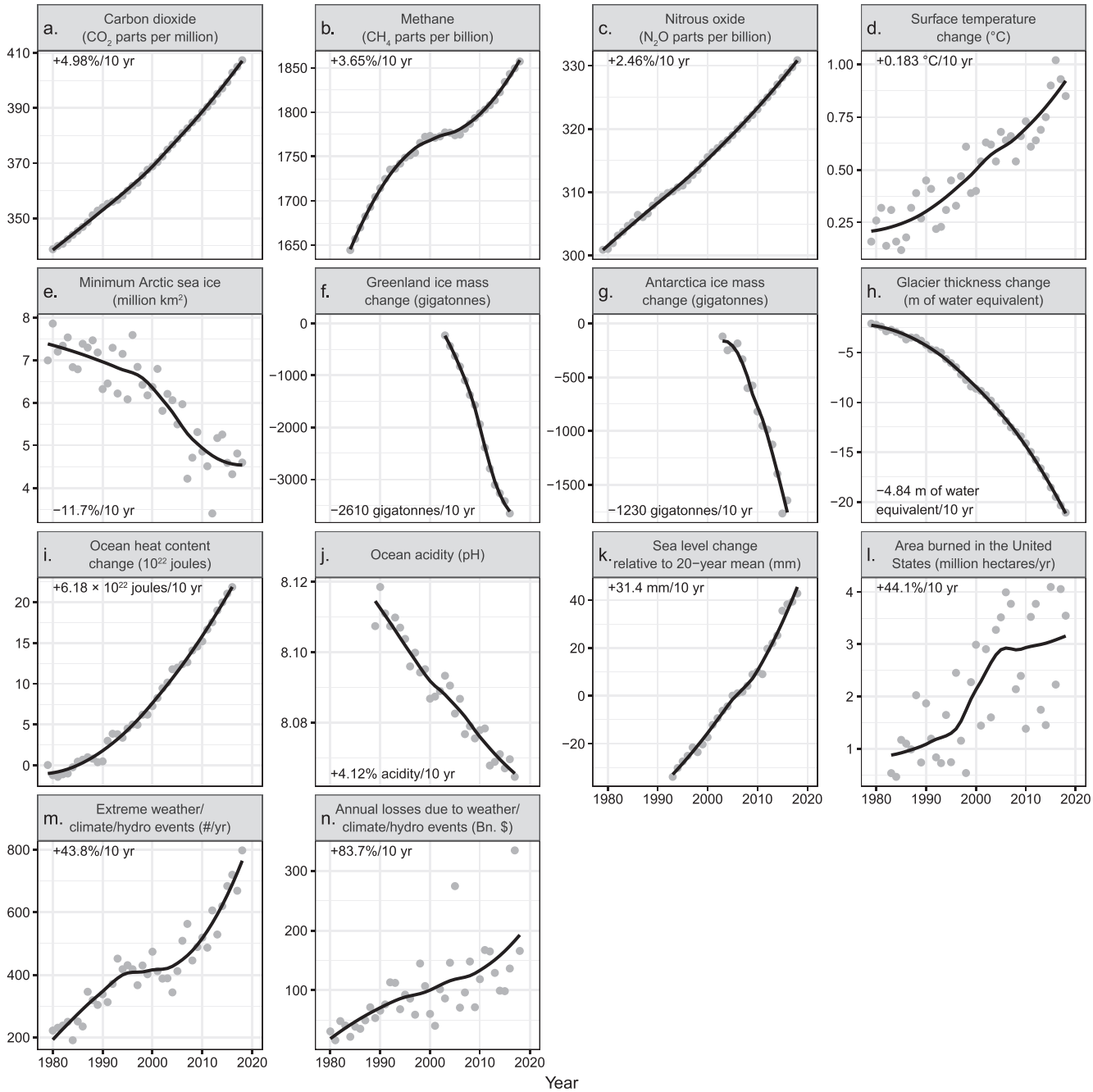

Figure 2. ***Climatic response time series from 1979 to the present. The rates shown in the panels are the decadal change rates for the entire ranges of the time series. These rates are in percentage terms, except for the interval variables (d, f, g, h, i, k), where additive changes are reported instead. For ocean acidity (pH), the percentage rate is based on the change in hydrogen ion activity, a_{H^+} (where lower pH values represent greater acidity). The annual data are shown using gray points. The black lines are local regression smooth trend lines. Sources and additional details about each variable are provided in supplemental file S2, including table S3.***

chain reactions could cause significant disruptions to ecosystems, society, and economies, potentially making large areas of Earth uninhabitable.

To secure a sustainable future, we must change how we live, in ways that improve the vital signs summarized by our graphs. Economic and population growth are among the most important drivers of increases in CO_2 emissions from fossil fuel combustion (Pachauri et al. 2014, Bongaarts and O'Neill 2018); therefore, we need bold and drastic transformations regarding economic and population policies. We suggest six critical and interrelated steps (in no particular order) that governments, businesses, and the rest of

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humanity can take to lessen the worst effects of climate change. These are important steps but are not the only actions needed or possible (Pachauri et al. 2014, IPCC 2018, 2019).

Energy

The world must quickly implement massive energy efficiency and conservation practices and must replace fossil fuels with low-carbon renewables (figure 1h) and other cleaner sources of energy if safe for people and the environment (figure S2). We should leave remaining stocks of fossil fuels in the ground (see the timelines in IPCC 2018) and should carefully pursue effective negative emissions using technology such as carbon extraction from the source and capture from the air and especially by enhancing natural systems (see "Nature" section). Wealthier countries need to support poorer nations in transitioning away from fossil fuels. We must swiftly eliminate subsidies for fossil fuels (figure 1o) and use effective and fair policies for steadily escalating carbon prices to restrain their use.

Short-lived pollutants

We need to promptly reduce the emissions of short-lived climate pollutants, including methane (figure 2b), black carbon (soot), and hydrofluorocarbons (HFCs). Doing this could slow climate feedback loops and potentially reduce the short-term warming trend by more than 50% over the next few decades while saving millions of lives and increasing crop yields due to reduced air pollution (Shindell et al. 2017). The 2016 Kigali amendment to phase down HFCs is welcomed.

Nature

We must protect and restore Earth's ecosystems. Phytoplankton, coral reefs, forests, savannas, grasslands, wetlands, peatlands, soils, mangroves, and sea grasses contribute greatly to sequestration of atmospheric CO_2. Marine and terrestrial plants, animals, and microorganisms play significant roles in carbon and nutrient cycling and storage. We need to quickly curtail habitat and biodiversity loss (figure 1f–1g), protecting the remaining primary and intact forests, especially those with high carbon stores and other forests with the capacity to rapidly sequester carbon (proforestation), while increasing reforestation and afforestation where appropriate at enormous scales. Although available land may be limiting in places, up to a third of emissions reductions needed by 2030 for the Paris agreement (less than 2°C) could be obtained with these natural climate solutions (Griscom et al. 2017).

Food

Eating mostly plant-based foods while reducing the global consumption of animal products (figure 1c–d), especially ruminant livestock (Ripple et al. 2014), can improve human health and significantly lower GHG emissions (including methane in the "Short-lived pollutants" step). Moreover, this will free up croplands for growing much-needed human plant food instead of livestock feed, while releasing some grazing land to support natural climate solutions (see "Nature" section). Cropping practices such as minimum tillage that increase soil carbon are vitally important. We need to drastically reduce the enormous amount of food waste around the world.

Economy

Excessive extraction of materials and overexploitation of ecosystems, driven by economic growth, must be quickly curtailed to maintain long-term sustainability of the biosphere. We need a carbon-free economy that explicitly addresses human dependence on the biosphere and policies that guide economic decisions accordingly. Our goals need to shift from GDP growth and the pursuit of affluence toward sustaining ecosystems and improving human well-being by prioritizing basic needs and reducing inequality.

Population

Still increasing by roughly 80 million people per year, or more than 200,000 per day (figure 1a–b), the world population must be stabilized—and, ideally, gradually reduced—within a framework that ensures social integrity. There are proven and effective policies that strengthen human rights while lowering fertility rates and lessening the impacts of population growth on GHG emissions and biodiversity loss. These policies make family-planning services available to all people, remove barriers to their access and achieve full gender equity, including primary and secondary education as a global norm for all, especially girls and young women (Bongaarts and O'Neill 2018).

Conclusions

Mitigating and adapting to climate change while honoring the diversity of humans entails major transformations in the ways our global society functions and interacts with natural ecosystems. We are encouraged by a recent surge of concern. Governmental bodies are making climate emergency declarations. Schoolchildren are striking. Ecocide lawsuits are proceeding in the courts. Grassroots citizen movements are demanding change, and many countries, states and provinces, cities, and businesses are responding.

As the Alliance of World Scientists, we stand ready to assist decision-makers in a just transition to a sustainable and equitable future. We urge widespread use of vital signs, which will better allow policymakers, the private sector, and the public to understand the magnitude of this crisis, track progress, and realign priorities for alleviating climate change. The good news is that such transformative change, with social and economic justice for all, promises far greater human well-being than does business as usual. We believe that the prospects will be greatest if decision-makers and all of humanity promptly respond to this warning and declaration of a climate emergency and act to sustain life on planet Earth, our only home.

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Project website

To view the Alliance of World Scientists website or to sign this article, go to https://scientistswarning.forestry.oregonstate.edu.

Supplemental material

Supplemental data are available at *BIOSCI* online. A list of the signatories appears in supplemental file S1.

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William J. Ripple (bill.ripple@oregonstate.edu) and Christopher Wolf (christopher.wolf@oregonstate.edu) are affiliated with the Department of Forest Ecosystems and Society at Oregon State University, in Corvallis and contributed equally to the work. Thomas M. Newsome is affiliated with the School of Life and Environmental Sciences at The University of Sydney, in Sydney, New South Wales, Australia. Phoebe Barnard is affiliated with the Conservation Biology Institute, in Corvallis, Oregon, and with the African Climate and Development Initiative, at the University of Cape Town, in Cape Town, South Africa. William R. Moomaw is affiliated with The Fletcher School and the Global Development and Environment Institute, at Tufts University, in Medford, Massachusetts.

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World Scientists' Warning to Humanity: A Second Notice

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, MAURO GALETTI, MOHAMMED ALAMGIR, EILEEN CRIST, MAHMOUD I. MAHMOUD, WILLIAM F. LAURANCE, and 15,364 scientist signatories from 184 countries

Twenty-five years ago, the Union of Concerned Scientists and more than 1700 independent scientists, including the majority of living Nobel laureates in the sciences, penned the 1992 "World Scientists' Warning to Humanity" (see supplemental file S1). These concerned professionals called on humankind to curtail environmental destruction and cautioned that "a great change in our stewardship of the Earth and the life on it is required, if vast human misery is to be avoided." In their manifesto, they showed that humans were on a collision course with the natural world. They expressed concern about current, impending, or potential damage on planet Earth involving ozone depletion, freshwater availability, marine life depletion, ocean dead zones, forest loss, biodiversity destruction, climate change, and continued human population growth. They proclaimed that fundamental changes were urgently needed to avoid the consequences our present course would bring.

The authors of the 1992 declaration feared that humanity was pushing Earth's ecosystems beyond their capacities to support the web of life. They described how we are fast approaching many of the limits of what the biosphere can tolerate without substantial and irreversible harm. The scientists pleaded that we stabilize the human population, describing how our large numbers—swelled by another 2 billion people since 1992, a 35 percent increase—exert stresses on Earth that can overwhelm other efforts to realize a sustainable future (Crist et al. 2017). They implored that we cut greenhouse gas (GHG) emissions and phase out fossil fuels, reduce deforestation, and reverse the trend of collapsing biodiversity.

On the twenty-fifth anniversary of their call, we look back at their warning and evaluate the human response by exploring available time-series data. Since 1992, with the exception of stabilizing the stratospheric ozone layer, humanity has failed to make sufficient progress in generally solving these foreseen environmental challenges, and alarmingly, most of them are getting far worse (figure 1, file S1). Especially troubling is the current trajectory of potentially catastrophic climate change due to rising GHGs from burning fossil fuels (Hansen et al. 2013), deforestation (Keenan et al. 2015), and agricultural production—particularly from farming ruminants for meat consumption (Ripple et al. 2014). Moreover, we have unleashed a mass extinction event, the sixth in roughly 540 million years, wherein many current life forms could be annihilated or at least committed to extinction by the end of this century.

Humanity is now being given a second notice, as illustrated by these alarming trends (figure 1). We are jeopardizing our future by not reining in our intense but geographically and demographically uneven material consumption and by not perceiving continued rapid population growth as a primary driver behind many ecological and even societal threats (Crist et al. 2017). By failing to adequately limit population growth, reassess the role of an economy rooted in growth, reduce greenhouse gases, incentivize renewable energy, protect habitat, restore ecosystems, curb pollution, halt defaunation, and constrain invasive alien species, humanity is not taking the urgent steps needed to safeguard our imperilled biosphere.

As most political leaders respond to pressure, scientists, media influencers, and lay citizens must insist that their governments take immediate action as a moral imperative to current and future generations of human and other life. With a groundswell of organized grassroots efforts, dogged opposition can be overcome and political leaders compelled to do the right thing. It is also time to re-examine and change our individual behaviors, including limiting our own reproduction (ideally to replacement level at most) and drastically diminishing our *per capita* consumption of fossil fuels, meat, and other resources.

The rapid global decline in ozone-depleting substances shows that we can make positive change when we act decisively. We have also made advancements in reducing extreme poverty and hunger (*www.worldbank.org*). Other notable progress (which does not yet show up in the global data sets in figure 1) include the rapid decline in fertility rates in many regions attributable to investments in girls' and women's education (*www.un.org/esa/population*), the promising decline in the rate of deforestation in some regions, and the rapid growth in the renewable-energy sector. We have learned much since 1992, but the advancement of urgently needed changes in environmental policy, human behavior, and global inequities is still far from sufficient.

Sustainability transitions come about in diverse ways, and all require civil-society pressure and evidence-based advocacy, political leadership, and a solid understanding of policy

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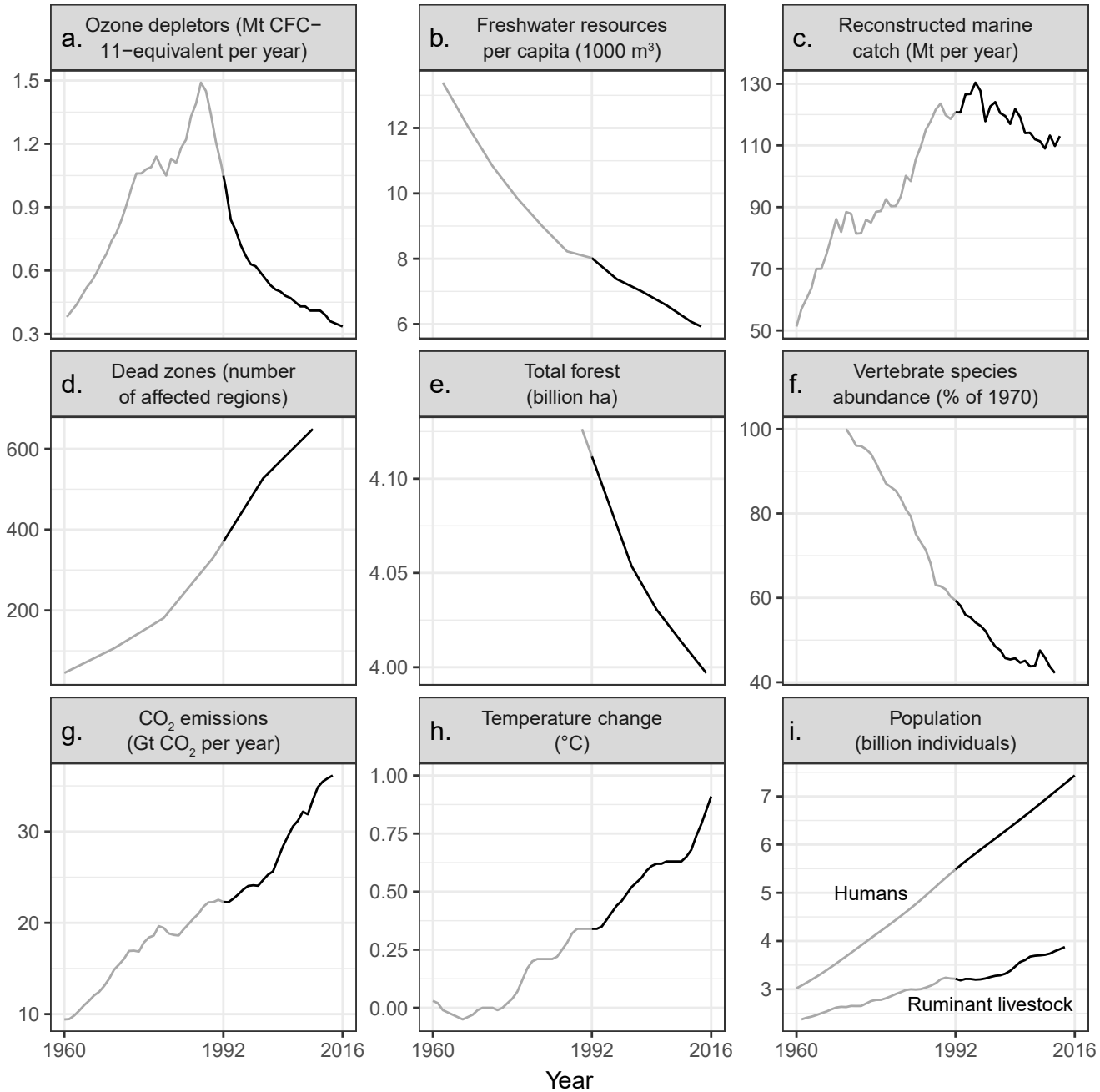

Figure 1. Trends over time for environmental issues identified in the 1992 scientists' warning to humanity. The years before and after the 1992 scientists' warning are shown as gray and black lines, respectively. Panel (a) shows emissions of halogen source gases, which deplete stratospheric ozone, assuming a constant natural emission rate of 0.11 Mt CFC-11-equivalent per year. In panel (c), marine catch has been going down since the mid-1990s, but at the same time, fishing effort has been going up (supplemental file S1). The vertebrate abundance index in panel (f) has been adjusted for taxonomic and geographic bias but incorporates relatively little data from developing countries, where there are the fewest studies; between 1970 and 2012, vertebrates declined by 58 percent, with freshwater, marine, and terrestrial populations declining by 81, 36, and 35 percent, respectively (file S1). Five-year means are shown in panel (h). In panel (i), ruminant livestock consist of domestic cattle, sheep, goats, and buffaloes. Note that y*-axes do not start at zero, and it is important to inspect the data range when interpreting each graph. Percentage change, since 1992, for the variables in each panel are as follows: (a) –68.1%; (b) –26.1%; (c) –6.4%; (d) +75.3%; (e) –2.8%; (f) –28.9%; (g) +62.1%; (h) +167.6%; and (i) humans: +35.5%, ruminant livestock: +20.5%. Additional descriptions of the variables and trends, as well as sources for figure 1, are included in file S1.*

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instruments, markets, and other drivers. Examples of diverse and effective steps humanity can take to transition to sustainability include the following (not in order of importance or urgency): (a) prioritizing the enactment of connected well-funded and well-managed reserves for a significant proportion of the world's terrestrial, marine, freshwater, and aerial habitats; (b) maintaining nature's ecosystem services by halting the conversion of forests, grasslands, and other native habitats; (c) restoring native plant communities at large scales, particularly forest landscapes; (d) rewilding regions with native species, especially apex predators, to restore ecological processes and dynamics; (e) developing and adopting adequate policy instruments to remedy defaunation, the poaching crisis, and the exploitation and trade of threatened species; (f) reducing food waste through education and better infrastructure; (g) promoting dietary shifts towards mostly plant-based foods; (h) further reducing fertility rates by ensuring that women and men have access to education and voluntary family-planning services, especially where such resources are still lacking; (i) increasing outdoor nature education for children, as well as the overall engagement of society in the appreciation of nature; (j) divesting of monetary investments and purchases to encourage positive environmental change; (k) devising and promoting new green technologies and massively adopting renewable energy sources while phasing out subsidies to energy production through fossil fuels; (l) revising our economy to reduce wealth inequality and ensure that prices, taxation, and incentive systems take into account the real costs which consumption patterns impose on our environment; and (m) estimating a scientifically defensible, sustainable human population size for the long term while rallying nations and leaders to support that vital goal.

To prevent widespread misery and catastrophic biodiversity loss, humanity must practice a more environmentally sustainable alternative to business as usual. This prescription was well articulated by the world's leading scientists 25 years ago, but in most respects, we have not heeded their warning. Soon it will be too late to shift course away from our failing trajectory, and time is running out. We must recognize, in our day-to-day lives and in our governing institutions, that Earth with all its life is our only home.

Epilogue

We have been overwhelmed with the support for our article and thank the more than 15,000 signatories from all ends of the Earth (see supplemental file S2 for list of signatories). As far as we know, this is the most scientists to ever co-sign and formally support a published journal article. In this paper, we have captured the environmental trends over the last 25 years, showed realistic concern, and suggested a few examples of possible remedies. Now, as an Alliance of World Scientists (*scientists.forestry.oregonstate.edu*) and with the public at large, it is important to continue this work to document challenges, as well as improved situations, and to develop clear, trackable, and practical solutions while communicating trends and needs to world leaders. Working together while respecting the diversity of people and opinions and the need for social justice around the world, we can make great progress for the sake of humanity and the planet on which we depend.

Spanish, Portuguese, and French versions of this article can be found in file S1.

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Supplemental material

Supplementary data are available at *BIOSCI* online including supplemental file 1 and supplemental file 2 (full list of all 15,364 signatories).

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William J. Ripple (bill.ripple@oregonstate.edu), Christopher Wolf, and Thomas M. Newsome are affiliated with the Global Trophic Cascades Program in the Department of Forest Ecosystems and Society at Oregon State University, in Corvallis. TMN is also affiliated with the Centre for Integrative Ecology at Deakin University, in Geelong, Australia, and the School of Life and Environmental Sciences at The University of Sydney, Australia. Mauro Galetti is affiliated with the Instituto de Biociências, Universidade Estadual Paulista, Departamento de Ecologia, in São Paulo, Brazil. Mohammed Alamgir is affiliated with the Institute of Forestry and Environmental Sciences at the University of Chittagong, in Bangladesh. Eileen Crist is affiliated with the Department of Science and Technology in Society at Virginia Tech, in Blacksburg. Mahmoud I. Mahmoud is affiliated with the ICT/Geographic Information Systems Unit of the National Oil Spill Detection and Response Agency (NOSDRA), in Abuja, Nigeria. William F. Laurance is affiliated with the Centre for Tropical Environmental and Sustainability Science and the College of Science and Engineering at James Cook University, in Cairns, Queensland, Australia.

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Research Station

General Technical
Report
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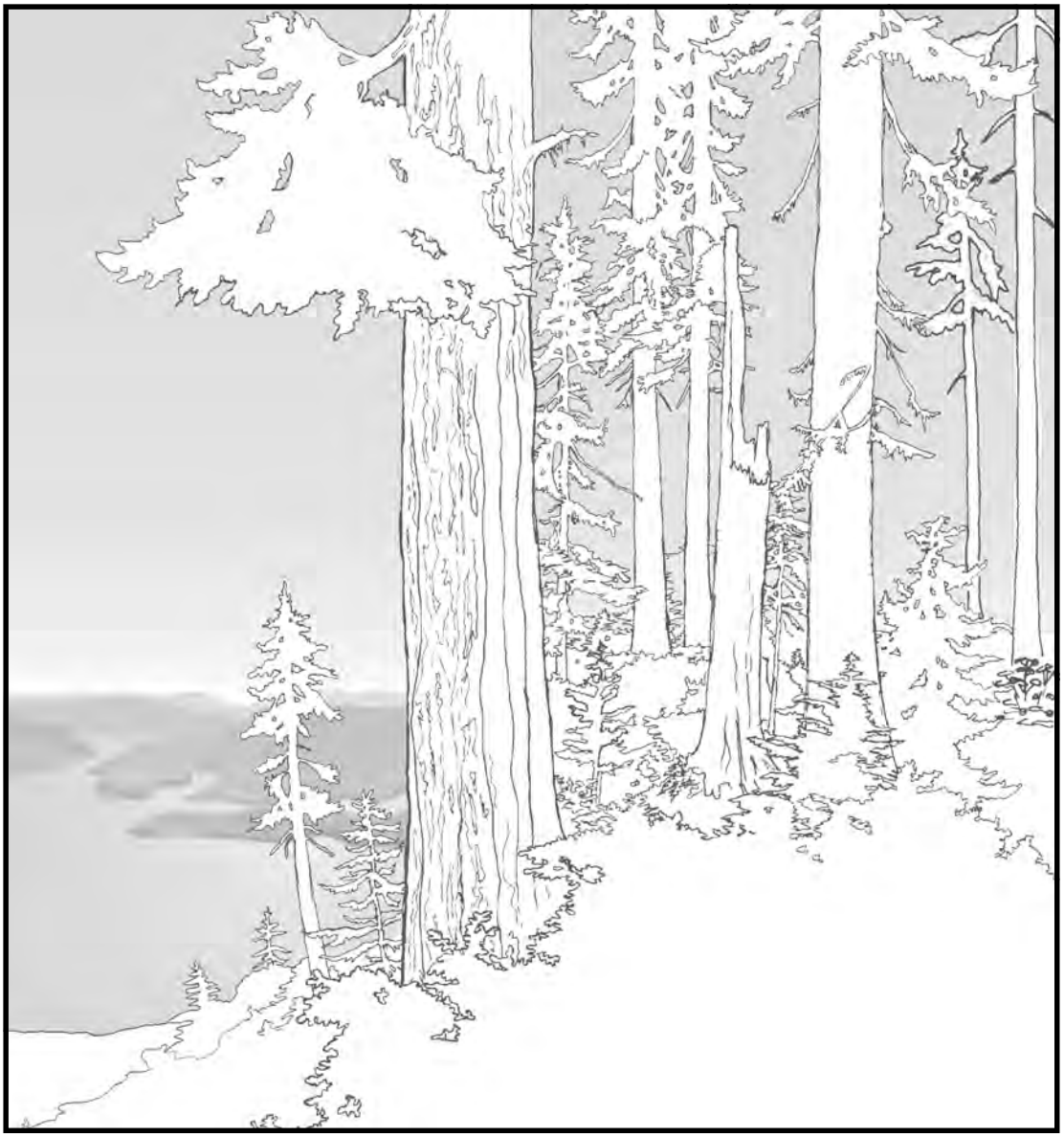
May 2001

Assessment of the Competitive Position of the Forest Products Sector in Southeast Alaska, 1985-94

Guy C. Robertson and David J. Brooks



Authors

Guy C. Robertson is a research economist, Forestry Sciences Laboratory, 2770 Sherwood Lane, Suite 2A, Juneau, AK 99801-8545; and **David J. Brooks** is a research forester, Forestry Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, OR 97331.

Abstract

Robertson, Guy C.; Brooks, David J. 2001. Assessment of the competitive position of the forest products sector in southeast Alaska, 1985-94. Gen. Tech. Rep. PNW-GTR-504. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 29 p.

This paper provides an assessment of the competitive position of the forest products sector in southeast Alaska relative to that of its major competitors. An analytical framework relying on the economic concepts of comparative and competitive advantage is first developed, with emphasis on the relative cost and productivity of productive inputs such as labor, capital, and raw materials. The assessment is divided into three main components: (1) forest resource characteristics and production costs in the logging sector, (2) production costs in the sawmill sector, and (3) relative market position in end-product markets. Major competing regions are British Columbia in Canada and the states of Washington and Oregon in the United States. Japan's market for soft-wood saw logs and sawn wood is the focus of the end-market analysis. Data consistently indicate that southeast Alaska has been a high-cost producer of sawn-wood products operating at the margin of profitability over the assessment period. This is due to a combination of high labor costs on a per-unit-of-input basis and low productivity for labor inputs in both the logging and sawmill sectors, and for raw material inputs in the sawmill sector. Certain species and log grades, however, are capable of generating considerable profits, and the relation between average profitability for the sum total of harvests in southeast Alaska and the profitability of specific components of this harvest also is analyzed. Implications of these findings for current efforts to promote increased value-added timber processing in southeast Alaska are discussed in the conclusion.

Keywords: Comparative advantage, labor productivity, timber scarcity, value added, stumpage prices.

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Introduction

An assessment of the competitive position of the forest products sector in southeast Alaska has important implications for various forest policy questions including current efforts to increase value-added processing in the region as well as the more general debate over harvest levels for the Tongass National Forest. Primarily because of its remote location, southeast Alaska generally has been recognized as a high-cost producer of wood products. On the other hand, some species and log grades harvested in southeast Alaska are capable of sustaining high market prices in some market cycles, thereby offsetting higher production costs. The objective of this assessment is to provide quantitative measures of production costs and product revenues for softwood lumber produced in southeast Alaska and to compare these data with similar measures for southeast Alaska's principal North American competitors. Although most of the assessment concentrates on average costs for timber harvested and processed in southeast Alaska, production costs and market prices for specific species also are included.

The first section of this assessment establishes a framework that can be used to assess the position of the wood products sector relative to that of its competitors and end markets in southeast Alaska. The economic concepts of comparative and competitive advantage are used to focus the analysis on the cost and utilization of productive inputs such as labor, capital, and for the sawmill sector, log inputs. In subsequent sections, this framework is used to organize data specific to southeast Alaska and to compare these measures with similar measures used in the coastal region of British Columbia in Canada and the Pacific Northwest region of the United States.

The body of the assessment focuses on specific aspects of the chain of events starting from the forest resource to the sale of processed products in final markets. Following a general overview of the wood products sector in southeast Alaska, logging costs and the composition of the forest resource are considered. Next, we discuss processing costs and efficiency in the sawmill sector. This is followed by an analysis of total lumber production costs. The relative position of southeast Alaska products in the Japanese market for softwood sawn wood is considered next. We then address the impact of production costs and market prices on the imputed "residual value" of stumpage (market prices minus production costs) and the observed prices received for the sale of timber in southeast Alaska, British Columbia, and the Pacific Northwest. As cost factors and their implications for comparative and competitive advantage are not static over time, the next to last section of this report concentrates on how southeast Alaska's regional comparative advantage in lumber production may be changing over time. The conclusion addresses the policy implications of the assessment.

Analytical Framework

Two main bodies of economic theory specifically address the position of a regional wood products sector relative to that of its major competitors. The first is the Hecksher-Ohlin trade theory (and variants thereof), which is summarized in the concept of comparative advantage. The second is found more often in the business and management literature and relates to the competitiveness of a firm, industry, or sector. Although competitiveness is defined in various ways, all definitions involve the ability to supply comparable goods at lower cost than major competitors. Before addressing their application to the southeast Alaska wood products sector, we will discuss each of these theories separately.

Comparative and Competitive Advantage

First described by the British economist David Ricardo in the early 19th century, the concept of comparative advantage today relies heavily on the work of Hecksher (1949 for example), Vanek (1963), and Ohlin (1967). Their work primarily explains trade patterns as a function of country-specific endowments of productive inputs (or "factors"),

which usually are restricted to labor and capital. Briefly stated, the theory of comparative advantage holds that a country will specialize in producing products that more intensively use productive factors that country has in relative abundance. Hence, developing countries, such as China, with large labor resources relative to the supply of capital inputs, will specialize in labor-intensive goods. Countries with large stocks of fixed and human capital such as the United States, on the other hand, will specialize in capital or information-intensive goods. This specialization and resulting trade, it is argued, maximizes welfare by efficiently allocating the productive resources of all traders.

A corollary to the concept of comparative advantage is that of factor price equalization, which holds that, in equilibrium, wages (including payments for capital) paid to similar productive factors will be equal across all trading countries. To continue with the above example of developing and developed countries, factor price equalization can readily be seen in the tendency of imports of labor-intensive manufactures from low-wage countries to depress wages for unskilled labor in the developed nations. Note that the quality of factor inputs must be similar, and labor skills must be taken into account. Here, skilled labor can be viewed as the combination of unskilled labor and human capital inputs (namely, education and experience).

Empirical work addressing comparative advantage has tended to concentrate on only the broadest aggregate measures, yielding general conclusions about the comparative advantage of nations but little information about specific regions or products. A common approach is to view the net balance of trade of a country in capital or labor-intensive goods as indicative of its comparative advantage in either of these categories. The share of the net trade of a given good in the country's total trade volume can then be used as a measure of comparative advantage. This is often termed "revealed comparative advantage." Econometric methods can then be used to estimate the relation between revealed competitive advantage and variously constructed indexes of the endowment of labor and capital of a country, both fixed and human (see Balassa 1978 for an example of this approach). Not surprisingly, empirical studies have found a consistent relation between capital endowments and net exports of capital-intensive goods.

Bonnefoi and Buongiorno (1990) provide a rare example of the application of this sort of method to trade in wood products. By regressing net trade of various wood products on total income and on proxies for capital endowments and forest resource endowments (represented by per capita income and total harvest, respectively), they were able to explain a relatively high proportion of the net international trade in processed wood products. They were not as successful, however, in explaining roundwood exports. Additionally, the influence of their capital proxy was generally insignificant in all but the paper and paper board sector. Given that total harvest was used as a proxy for forest resource endowments, results of the study simply state that those countries with high levels of harvest relative to the size of their economies are more apt to export wood products either in raw or in processed form. An additional conclusion is that countries with high capital endowments are more apt to export paper products.

Bonnefoi and Buongiorno (1990) highlight the difficulty in incorporating forest resources as a productive factor in a comparative-advantage analysis. The problem involves measuring the relative abundance or scarcity of a natural resource in economic terms. A substantial amount of literature addresses this question for nonrenewable resources (for example, Smith 1980, Solow 1974). Berk (1979) provides an often-cited example of a forestry-related application, and Catimel (1996) provides a general discussion of the

relation of scarcity, comparative advantage, and trade in Canada's forest products sector. Although stumpage prices (the price of standing timber) and harvest costs have been proposed as two possible measures of scarcity, both entail certain problems, and there is no broad agreement on an accepted or unambiguous measure of timber scarcity in the literature on the topic.

Competitiveness

The second of economic theory applied in this assessment is that of competitiveness. Brinkman (1987) provides two definitions of competitiveness: (1) "market competitiveness," which refers to the ability of an industry to supply comparable goods at a lower cost than other producers; and (2) "true competitiveness," which is defined as the ability of an industry to provide goods to the international market in competition with other producers such that the activity augments the wealth of the nation. This second definition addresses the need to consider the total costs and benefits accruing from production activities. These include government subsidies, and economic externalities affecting both market and nonmarket values. For this assessment, we concentrate on the first definition, although issues such as direct subsidies and environmental externalities are recognized as being important to forest management.

The literature on competitiveness is both voluminous and diffuse, ranging from theoretical discussions of the tangible and intangible elements that affect the competitive position of firms, industries, and nations (for example, Coffin and others 1993, Porter 1990) to more practical analyses of industry cost structures and markets. Indeed, many of the articles found in the trade journals as well as many university and public sector working papers fall into this latter category. Similarly, this report relies extensively on the measurement and analysis of production costs and end-market price behavior as indicators of competitiveness.

Although closely related, competitiveness and comparative advantage are not the same. Comparative advantage is an equilibrium concept. At economic equilibrium, factor prices, and therefore production costs, will be equal for all trading partners. Advantage will be measured solely by the relative volumes of production and trade of different types of goods. Competitive advantage, on the other hand, relies on the existence of disequilibria. Here, different technologies and factor wages result in different production costs for similar goods. The country (or region) demonstrating the lower cost possesses a competitive advantage. To the extent that factor wages reflect the economic fundamentals of a country or region, and not market distortions, competitive advantage will reflect an underlying comparative advantage. In this case, the expected market equilibrium has not yet been reached. Economic theory would predict that this competitive advantage will result in increased production volumes and relative trade shares. At the same time, increased local demand for productive factors, and increased supply of the final product in export markets will result in the equalization of factor wages. Consequently, competitiveness can be used (with proper care) to predict future economic developments: countries with a competitive advantage in a given industry can expect increasing production and export market shares in that industry. Also, if the supply of productive factors used in that industry is constrained, the country can expect increasing wages to those factors. For competitive disadvantage, the exact opposite is the case.

Factor Inputs and Stumpage Prices

The application of this argument to the wood products sector is complicated by the fact that timber is a major component in the input mix. As demonstrated by Berk (1979), and further evidenced by positive stumpage prices, timber is a scarce resource, at least in the short run. This is especially true for the high-quality, old-growth timber that comprises a proportion of southeast Alaska harvests. High scarcity values for the timber

(referred to as “scarcity rents” by economists) will be reflected in high market prices for logs or lumber products. Stumpage prices will partially reflect these scarcity rents. The production of logs, however, will entail the use of other inputs, and the cost of these inputs also will be incorporated in the stumpage value of the resource. Here, the stumpage price can be seen as a residual value that measures the final market price of the logs minus the cost of their production. Using an example that also fore-shadows the conclusions of this paper, consider a region with high labor costs but also high scarcity rents associated with its timber. Although the region will be at a competitive disadvantage in logging per se, it still may have an advantage in log production if the scarcity value of the timber is high enough to compensate for the higher cost of labor.

This sort of competitive advantage based on scarcity value, however, cannot always be used as a predictor of future increases in production volumes. The scarce resource is, by definition, depletable. With old-growth timber, the limited volume of accessible timber may severely constrain increases in production. Even with second-growth or plantation timber, currently available supply will be dictated by investments made years ago, sometimes under different economic conditions. Before physical depletion of supply is reached, production costs can be expected to rise at an increasing rate as producers are forced to harvest more inaccessible stands. For certain stands, these costs will exhaust even relatively high timber scarcity rents, and the resulting negative residual values (or zero stumpage prices) will clearly signal a lack of profitability and competitive advantage in the sector. In addition to changing production costs, the sector also may face cyclic swings in the demand for its product. Such swings are well known in the wood products sector. The resulting price fluctuations will be reflected in changing stumpage values, and once again, negative profitability during some portions of the market cycle.

The previously mentioned arguments suggest two ways to measure competitiveness: production costs and profitability—essentially two sides of the same coin. Production costs can be estimated by examining the productivity and wages of specific factors. For example, hourly wages can be combined with labor hours per unit of output to derive a unit cost for labor. The latter can be estimated by examining stumpage prices or calculating residual values. In the following analysis, these measures for southeast Alaska are compared with those for the Pacific Northwest and British Columbia. Throughout, it is important to view specific products as a combination of factor inputs, and the production process as a whole as a process that seeks to efficiently allocate the use of these factors. Subject to the limitations of technology and often policy, firms will attempt to maximize the use of factors that are cheap relative to other producers and minimize the use of those that are expensive.

The Wood Products Sector in Southeast Alaska

Rigorous application of the theories described previously to the question of comparative and competitive advantage of southeast Alaska is complicated by the lack of adequate comparable data for the region and its competitors, the relative absence of competitive stumpage markets in the region, and the general complexity of the wood products sector. For southeast Alaska, these complexities include physical and policy-induced resource constraints and the potential to produce various products in different locations. Rather than presenting an abstract but complete picture of the competitive position of the region, the present analysis is more similar to putting together a puzzle where some of the pieces are missing. Consequently, the following sections present evidence of the relative position of the region in a somewhat piecemeal fashion by using available data and making comparisons where possible. Different stages in the production and marketing process are used as the principle means to organize these data and their comparisons.

Figure 1 provides a schematic diagram of the wood products sector, which identifies major production stages and key elements that combine to determine competitiveness. Three broad areas of analysis are indicated: (1) the forest resource in which timber stocks are combined with labor, machinery, and other inputs to produce raw logs; (2) the processing sector in which logs are combined with other factors to produce products such as lumber and chips (including mill residues); and (3) end markets where purchasers compare the price and physical characteristics of southeast Alaska products to those from other regions. These purchasers include both manufacturers and final consumers. Factor costs include wages, interest (the opportunity cost of invested capital), and costs for other materials and services. The physical characteristics of timber contribute to the determination of competitive status through their effect on the quantity and cost of other factor inputs needed to both manufacture and use products from southeast Alaska, and the range, quantity, and quality of products that may be supplied. Finally, end-market demand shifters such as construction activity and consumer preferences in conjunction with the availability of substitute products will help determine product prices.

Along the bottom portion of figure 1, the concept of stumpage price as a residual value also is displayed. Given the assumption of perfect information and competitive markets, the difference between final price and production costs will be “bid back to the stump” or, in other words, concentrated in the stumpage price. The validity of these two assumptions, however, particularly that of perfect information, is open to question. Stumpage prices are perhaps better viewed as emerging from a separate stumpage market in which purchasers bid based on expected profits and thus include their expectations of future price fluctuations and their attitude toward risk. In spite of the intervening influence of these and other factors in stumpage markets, the connection between stumpage prices and residual values nonetheless remains a strong one. Both measures will be examined in the following analysis.

Data for this report were drawn from various sources. The physical characteristics of the forest resource are analyzed by using historical data on southeast Alaska log production by species and grade. Pond log values, mill prices (or export prices as reported by the U.S. Department of Commerce [as reported in Warren 1998]), and end-market prices in Japan comprise our primary sources of price data at different stages of the production process. For estimates of harvest and processing costs, we have relied on USDA Forest Service sale appraisal data and industry survey data[1] available from outside sources. Our discussion of factor costs focuses on relative wage rates as reported by the U.S. Bureau of the Census, Annual Survey of Manufactures.

Cost estimates from the sale appraisal process are a major source of information used in this report. These estimates, however, are based on historical industry conditions (as reflected in Forest Service cost collection surveys), and these conditions have changed considerably in recent years as the sector has adjusted to the closure of the region’s remaining pulp mill in Ketchikan and a general reduction in sawmill capacity. Additionally, new production facilities are being considered. These developments could substantially alter the costs reported in the sale appraisal process as well as the general economics surrounding the Forest Service’s sale program. Census of Manufactures

[1] U.S. Department of Agriculture, Forest Service. 1984-94. Sale appraisal data. Unpublished data. On file with: USDA Forest Service, Forest Management Division, Alaska Region, P.O. Box 21628, Juneau, AK 99802.

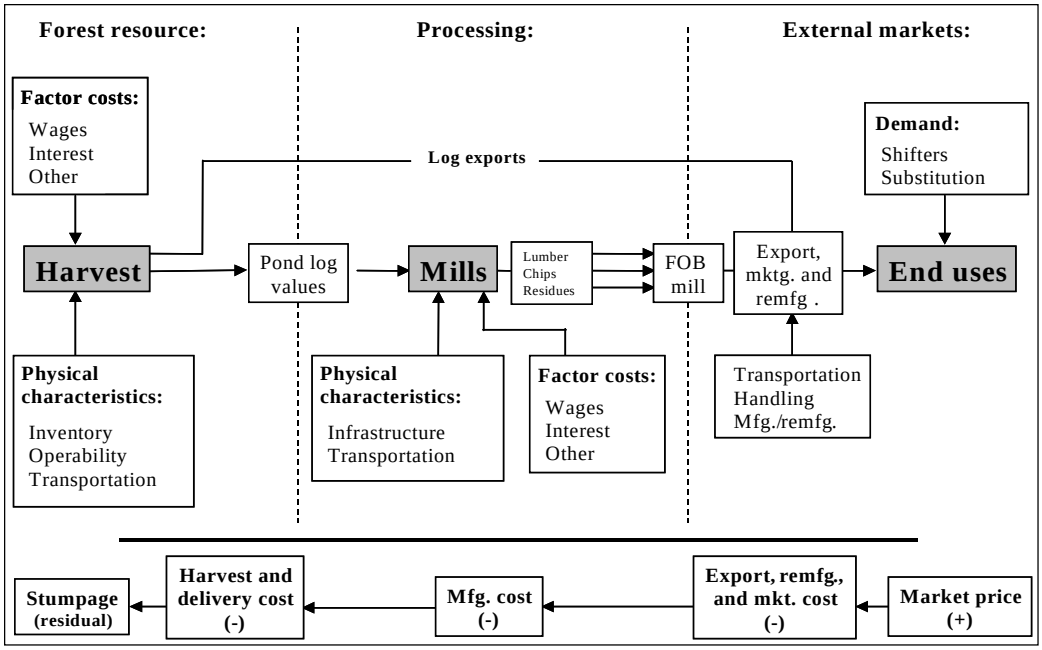

Figure 1—Sources of comparative and competitive advantage in the wood products sector.

wage and labor input data, on the other hand, provide a more independent (but significantly less detailed) assessment of costs faced by southeast Alaska producers. These data reflect more fundamental economic conditions in southeast Alaska, and they generally corroborate the conclusions found in the analysis of the sale appraisal data.

The Forest Resource

Physical Characteristics

Although in certain years Alaska has imported pulpwood and mill residues, these imports are small and largely irrelevant to the assessment of southeast Alaska's competitive and comparative advantage. In the absence of imported raw timber, the quantity and the physical characteristics of the forest resource in southeast Alaska define the upper boundary of how much and what sorts of wood products the region may produce. For the Tongass National Forest, this boundary will be further constrained by several forest regulations, including designations of the suitable timber base and constraints on harvest designed to ensure sustainability and guard against high grading (that is, harvesting only the better trees or stands). Restrictions on exports of raw material from the Tongass National Forest currently limit log exports of federal timber to Alaska yellow cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) and a proportion of the western redcedar harvest (*Thuja plicata* Donn ex D. Don). This ban applies to all sales outside the region. The Tongass National Forest timber base is the major focus of this part of the report, and the private forests of southeast Alaska will be discussed primarily in terms of their impact on Tongass National Forest harvests and subsequent processed goods. Additionally, we have concentrated on only the existing timber stock; future second-growth timber supplies and issues of forest productivity are not considered.

The distribution of harvest by species and log grades is largely determined by the forest resource, particularly if proportionality requirements restricting high grading at the stand or forest level are in place. In table 1, we present 1995 statistics for harvest by species and grade for southeast Alaska and British Columbia (similar data are not readily available for the Pacific Northwest). Estimates for southeast Alaska are based on Alaska Region log scaling tickets, whereas for British Columbia estimates are from

Table 1—Distribution of 1995 harvest by species and grade, coastal British Columbia and southeast Alaska

Species and location	Premium saw log	Saw log	Low-grade saw log	Utility	Species share (of total harvest)
			Percent		
Sitka spruce:					
British Columbia	14.6	61.8	10.0	13.6	1.9
Southeast Alaska	17.4	52.7	11.3	18.6	23.8
Hemlock:					
British Columbia	3.7	46.9	17.0	32.4	15.6
Southeast Alaska	7.2	41.2	24.8	26.8	58.3

Note: Southeast Alaska log classes are translated as follows: premium saw log = no. 1 saw log, select and special mill; saw log = no. 2 saw log; low-grade saw log = no. 3 and no. 4 saw logs; utility = utility logs.
Source: USDA Forest Service (1984-94), British Columbia Council of Forest Industries (see footnote 3).

the Vancouver log market.[2 3] In general, log class distributions are similar across regions, with a high concentration of volume in the saw log class (number 2 saw logs in southeast Alaska), and a higher proportion of volume in the lower grades for western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) than for Sitka spruce (*Picea sitchensis* (Bong.) Carr.). Although there are higher percentages in the premium grade for southeast Alaska, this could possibly be an artifact of the different log classification systems used for each region.

A more striking difference is found in the comparison of the shares of Sitka spruce in total production. Because of the relatively small share of Sitka spruce in British Columbia total volume, spruce volumes supplied in 1995 are small in spite of the overall position of British Columbia as a major forest products producer. In that year, southeast Alaska accounted for about 70 percent of estimated total North American production of Sitka spruce (42 percent from private owners and 28 percent from the Tongass National Forest) with British Columbia accounting for the remainder. This highlights the special position southeast Alaska enjoys as the world's major producer of Sitka spruce. For hemlock, however, the situation is reversed. Southeast Alaska accounts for around 17 percent (private 11 percent and Tongass National Forest 6 percent) of total western hemlock production for export to Pacific Rim markets; British Columbia, at 59 percent, accounts for most of the western hemlock production, and the Pacific Northwest accounts for most of the remaining 23 percent. If Pacific Northwest production for U.S. domestic markets were included in this calculation, southeast Alaska's share of total hemlock production would be significantly smaller. The role of the region as a principal

[2] Although the southeast Alaska log ticket data purportedly comprise a census of total Tongass National Forest log production, analysis indicates that a small proportion of log production is not recorded. Nevertheless, it seems safe to assume that the sample is representative. The Vancouver log market, on the other hand, constitutes only a minority share of total British Columbia coastal log production. We have no reason, however, to believe that the sample differs systematically from the whole.

[3] British Columbia log market prices and volumes. Unpublished data. On file with: British Columbia Council of Forest Industries, 1200-555 Burrard Street, Vancouver, BC V7X 1S7, Canada.

supplier of Sitka spruce and a relatively minor sup-plier of hemlock has important implications when analyzed in conjunction with the end markets for each of these species, and they will be discussed further in later sections of this report.

Harvest Costs

Harvest costs per thousand board feet log scale[4] for southeast Alaska, the Pacific Northwest, and British Columbia are displayed in figure 2. Figures for southeast Alaska were estimated by using Forest Service sale appraisal data from independent sales, and they represent an appraised cost rather than actual transactions (Western Pine Association).[5] Data for the Pacific Northwest and British Columbia were obtained from a private mill survey and represent actual costs as reported by respondents (Resource Information Systems, Inc. [RISI] 1996). The figure clearly indicates a similarity in both levels and trends between southeast Alaska and British Columbia and a large discrepancy between these series and that for the Pacific Northwest. As will be shown in subsequent sections, the similarity between southeast Alaska and British Columbia also is reflected in delivered wood costs (or pond log values). Though accessibility is a factor, the increasing trend in harvest costs in southeast Alaska most likely is due to decreases in both average piece size and volumes per acre. National forest sales in the Pacific Northwest likely have experienced similar increases in cost because of these same factors and from a related expansion in the use of helicopter logging systems. Regional Pacific Northwest averages, however, may have been held in check by an increasing proportion of private volumes in the total mix, and the greater accessibility and more uniform characteristics of the second-growth private resource. In any event, these data show a large and expanding cost differential between southeast Alaska and the Pacific Northwest.

British Columbia has the highest harvest costs of the three regions, which likely is due in part to similar resource characteristics as those encountered in southeast Alaska. Firms in British Columbia, however, operate in a substantially different macroeconomic environment, thereby making direct comparisons of costs with U.S. producers problematic. Trends, on the other hand, are more amenable to comparison. Most harvests in both regions are concentrated in old-growth timber and thus occur at the extensive margin of timber production. As old-growth stocks are liquidated, increasing costs over

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[4] Log scale (broad feet log scale) refers to a Scribner measurement in which round logs are converted into the number of board feet lumber tally (board feet lumber to tally a square foot of lumber 1 inch thick), which can be produced from these logs. Initially, board feet log scale and board feet lumber to tally were theoretically identical, but increasing lumber recovery and variations among different regions and different log sizes mean that the two measures are not the same. Converting broad feet log scale to broad feet lumber to tally entails an estimate of the physical conversion of logs to lumber at the mill. This issue is further addressed in the subsequent section on log conversion efficiency and overrun.

[5] Here we have used volume weighted yearly averages from the Forest Service form FS 2400-17 (line 29, logging costs net of specified road construction). These figures represent Forest Service estimates of expected costs and not actual costs incurred by harvest. The lack of an adequate sample size (particularly in 1986) is a problem, but the estimates generally conform to expectations and seem to be relatively stable (though slightly increasing) over time. Note that the extension of this series to the entire Tongass National Forest requires the assumption that the long-term contract sales exhibit the same cost parameters as the independent sales.

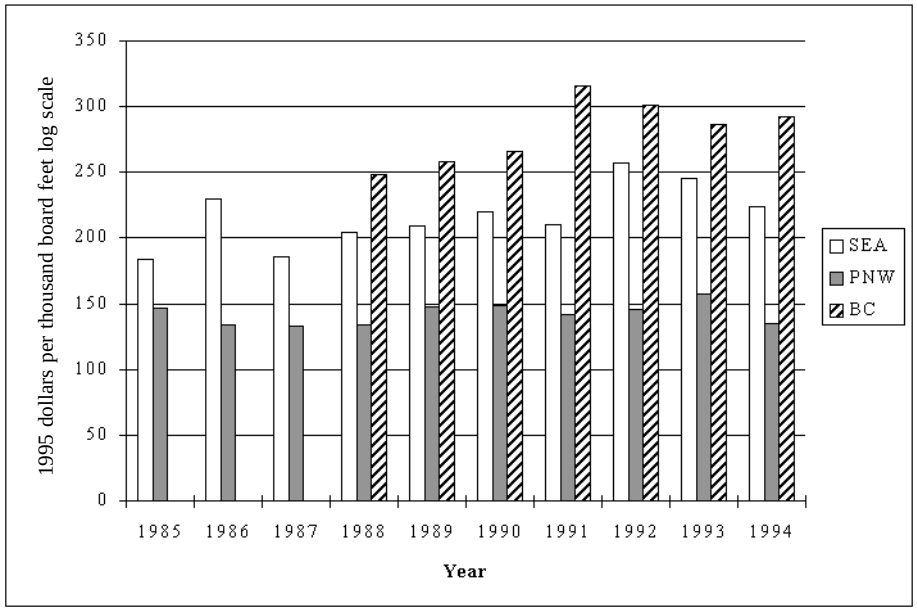

Figure 2—Harvest costs in southeast Alaska, the Pacific Northwest, and British Columbia. All estimates exclude permanent roading costs (from USDA Forest Service, Alaska Region, timber sale appraisal data [see footnote 1]; RISI 1996).

time can be expected. This is in contrast to the Pacific Northwest, where second-growth timber constitutes a substantial and increasing majority of total harvest, a trend which was accelerated by the recent declines in harvests from public lands in the region.

Table 2 displays a more detailed description of southeast Alaska-appraised logging costs as estimated from the sale appraisal data. The major cost categories include skidding and loading (44 percent of 1985-94 average total logging costs), transportation to mill (16 percent), and felling and bucking (12 percent). Specified roads are counted as separate for the application of purchaser road credits. They accounted for 15 percent of total appraised logging costs in the 1985-94 period. The total change over the sample period is reported in the last column of table 2. The $26-increase in skidding and loading (an estimated 3.7-percent annual rate of increase) is the largest increase for any single category and accounts for over half of the total increase in logging costs. Costs in this category will be sensitive to several factors, operability and log size being chief among them. In contrast to the “logging cost” subtotal, “total logging costs” experienced slight gains over the sample period, but this is due to a zero reported specified road cost in the final year, an anomaly which disguises a generally upward trend in these costs as well (note that only one sale was available for the 1994 sample).

Factor Costs and Intensity in the Logging Sector

The physical characteristics of the forest will largely determine the quantity and mix of productive factors used to harvest a given quantity of timber. Although economic theory predicts the marginal substitution of factors (capital for labor, for example) because of changes in relative factor wages, production technologies in the real world are less flexible. Logging firms will combine various productive inputs based on a limited menu of possible logging techniques. Consequently, the ability to adjust the mix of inputs may be limited. When combined with wage rates, the use of these factors will determine total production costs. Table 3 displays labor cost statistics for Alaska and for the

Table 2—Southeast Alaska logging costs from sale appraisal sample (1995 dollars per thousand board feet log sacle[a])

Category and sample	Year										1985-94 change
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	
	Dollars										
Cost category:											
Felling and bucking	28	41	33	29	31	29	28	35	24	24	-4
Skid and load	84	117	95	101	106	121	114	147	133	110	26
Haul dump raft and tow	45	44	36	45	39	37	37	38	44	51	6
Road maintenance	3	3	3	5	4	2	4	5	4	8	5
Temporary roads	11	22	15	14	17	19	14	15	13	7	-4
Other	13	2	4	10	13	13	12	16	20	24	11
Logging cost (subtotal)	184	230	186	205	210	220	210	257	237	224	40
Specified road costs	32	0	45	55	43	65	41	48	65	0	-32
Total logging costs	216	230	231	260	253	285	251	305	302	224	8
Sample information:											
Sample size	3	1	8	8	5	7	7	7	10	1	
Total volume of sales (MMbf)[b]	121	5	88	118	38	55	34	36	115	2	

[a] LS = log scale. See footnote 2 in the text for explanation of measurement units.
[b] MMbf = million board feet.
Source: USDA Forest Service, Alaska Region, timber sale appraisal data, (see footnote 1).

Table 3—Labor inputs in the logging sector, Alaska, Oregon, and Washington (1987-94)

Labor inputs by region	Year									Yearly growth
	1987	1988	1989	1990	1991	1992	1993	1994	Average	
	Hours									*Percent*
Logging production hours per Mbf ls:[a]										
Alaska	3.59	2.79	3.32	3.47	3.61	3.23	3.57	5.56	3.64	5.20
Pacific Northwest	2.37	2.45	2.35	2.64	2.58	2.78	3.02	3.38	2.7	4.90
Difference (%)	52	14	41	31	40	16	18	65	35	—
	Dollars									
Logging production wage (1995 $ per hour):										
Alaska	17.33	15.91	17.43	16.63	17.53	17.96	16.96	15.24	16.87	-0.50
Pacific Northwest	14.14	13.52	14.22	13.68	14.13	13.73	13.37	13.41	13.77	-.60
Difference (%)	23	18	23	22	24	31	27	14	23	—
	Dollars									
Unit labor cost (1995 $ per Mbf ls):[a]										
Alaska	62.29	44.36	57.84	57.63	63.35	57.99	60.47	84.74	61.08	4.60
Pacific Northwest	33.47	33.06	33.38	36.15	36.51	38.15	40.41	45.27	37.05	4.30
Difference (%)	86	34	73	59	74	52	50	87	65	—
Difference	28.82	11.3	24.47	21.48	26.84	19.84	20.05	39.47	24.03	—

[a] Mbf = thousand board feet log scale.
Source: U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures (1985-94).

Pacific Northwest as represented by an Oregon-Washington average (comparable data were not available for British Columbia). These data were obtained from the Bureau of Census' Survey of Manufactures and are reported for production workers; that is, workers directly engaged in production as opposed to those engaged in management and support.

As shown in the upper rows of table 3, Alaska used an average of 3.6 hours of production worker labor per thousand board feet log scale of lumber output over the 1987-94 period. The Pacific Northwest used 2.7 hours—a difference of 35 percent. Each of the years reported likewise shows a significantly higher labor intensity in logging production in Alaska, and though each region shows a generally increasing trend over time, there is no significant trend in the difference between them. As noted in the analysis of the sale appraisal data, the most likely explanation for higher labor intensity in Alaska relates to its remoteness and more difficult terrain, conditions which preclude certain mechanized harvesting operations and which necessitate higher labor inputs even under comparable harvest systems. Smaller average log sizes in Alaska also may play an important role in dictating lower labor productivity.

Relative wages are a function of both industry-specific conditions and of other factors affecting the regional labor market as a whole (which will be discussed in a latter section). As in the case of labor intensity, wages in the Alaska logging sector are consistently and significantly higher than those in the Pacific Northwest, and there is no discernible trend, either increasing or decreasing, in their relation.

By combining labor intensity and wages, we may obtain a measure of the unit cost of labor in the logging sector (in other words, the labor costs incurred in the production of one thousand board feet log scale; see the bottom rows of table 3). The combined effect of the higher labor intensity and higher wages in Alaska is evident in the estimated average unit labor cost differential (65 percent) between Alaska and the Pacific Northwest. This translates into an extra $24 per thousand board feet log scale in labor costs, which Alaska must pay on average over and above costs paid in the Pacific Northwest. This differential applies only to those employment categories that are explicitly coded as logging; if the case is similar for other labor inputs (such as those engaged in road construction), then the total per thousand board feet labor cost differential will accordingly be higher. In terms of relative levels, the labor cost data presented here mirrors the total harvest cost estimates presented above, but the divergence of trends apparent in the total cost data is not evident here; costs in both regions are increasing at essentially the same rate (see table 3 last column). Given the short timespan considered and the high year-on-year variation in the labor cost data, however, these trend estimates are far less robust than the estimates of average levels for the entire period.

Other factor costs include capital costs (interest on loans and the opportunity cost of invested capital), energy costs, the cost of other materials (including stumpage costs), and various other costs such as road construction and transportation. Although labor statistics are covered by federal and state reporting agencies, information on other factor inputs is largely unavailable, and it was not possible in this report to derive unit cost measures for other inputs. Labor cost differentials may nonetheless be indicative of the relative cost of other inputs in southeast Alaska. Higher wages reflect a higher overall cost of living for the region (the cost of living allowance for federal employees in Alaska, for example, is 25 percent). This higher cost also generally will apply to production activities as well as consumption.

Capital costs in the region, as measured by interest rates, may be assumed to be equivalent to that for investments of comparable risk in the Pacific Northwest as capital markets are well integrated at the national and, increasingly, international levels.[6] Capital inputs per Mbf harvested in Alaska, however, may well be higher due to more difficult operating conditions and the absence of road transportation networks. Indeed, if we assume similar capital to labor ratios in both regions, then unit capital inputs will exceed those in the Pacific Northwest by the same amount as the unit labor input. For similar reasons, inputs of other materials and services generally will be higher in southeast Alaska than in the Pacific Northwest. Thus, even assuming wages for these inputs are similar to those in the Pacific Northwest, costs will be higher because of lower productivity. Wages for these inputs, however, are likely to be higher owing to the generally higher costs endemic to the local economy.

The Manufacturing Sector

This section focuses on lumber production, again concentrating on unit labor costs arising from the combined influence of productivity and wages. More so than in the logging sector, the distribution of fixed capital investments in the region will help determine the productivity of other inputs (notably labor) and thereby overall production costs. Closure of the Ketchikan Pulp Company's mill in Ketchikan in 1997 brought pulp production in the region to an end; consequently, lumber, wood chips, and panel products remain as the most viable commodity options for the wood products sector in the foreseeable future.[7] A laminated veneer lumber plant is planned for the region, but it is not yet installed. Changes of this sort may somewhat alter labor productivity statistics for the sector, but underlying fundamentals determining comparative and competitive advantage will remain the same. In addition to revenues from lumber sales, the sale or other use of mill residuals (sawdust and chips) often will play a key role in mill profitability. Because of a lack of data, however, this role could not be directly analyzed in this report. Nonetheless, the general wage and productivity information, which is part of the following analysis, will have implications for the production of all mill products, including residuals.

Total Manufacturing Costs in the Sawmilling Sector

Total sawmilling costs net of the cost of wood inputs for southeast Alaska, the Pacific Northwest, and British Columbia are shown in figure 3. The figures here are reported in terms of thousand board feet log scale, and the sources for the Pacific Northwest and British Columbia are the same as those cited for logging costs. Figures for southeast Alaska were obtained from the "midmarket analysis," a component of the Forest Service sale appraisal process (see footnote 1). They constitute an average manufacturing cost for all species milled in southeast Alaska, meaning western hemlock and Sitka spruce for all practical purposes. Once again, southeast Alaska costs are significantly higher than those for the Pacific Northwest, ranging from 19 percent higher in 1984 to about twice the Pacific Northwest figure throughout the 1991-94 period.

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[6] Because of current policy in southeast Alaska, private firms have identified uncertainity as a major impediment to obtaining financing for new production capacity, which in turn, signifies a higher interest rate within the sector owing to higher risk. This higher capital cost, however, is a reflection of the current state of the sector and does not constitute an exogenous input cost. Given identical risk and potential for profit, interest rates in southeast Alaska should match those in the Pacific Northwest and elsewhere.

[7] In addition to these products, several specialty wood products are manufactured in southeast Alaska, with music-wood as the most visible example. The dynamics of this sector, however, are considerably different from those in main-stream commodity production, and specialty wood products are beyond the scope of the present analysis.

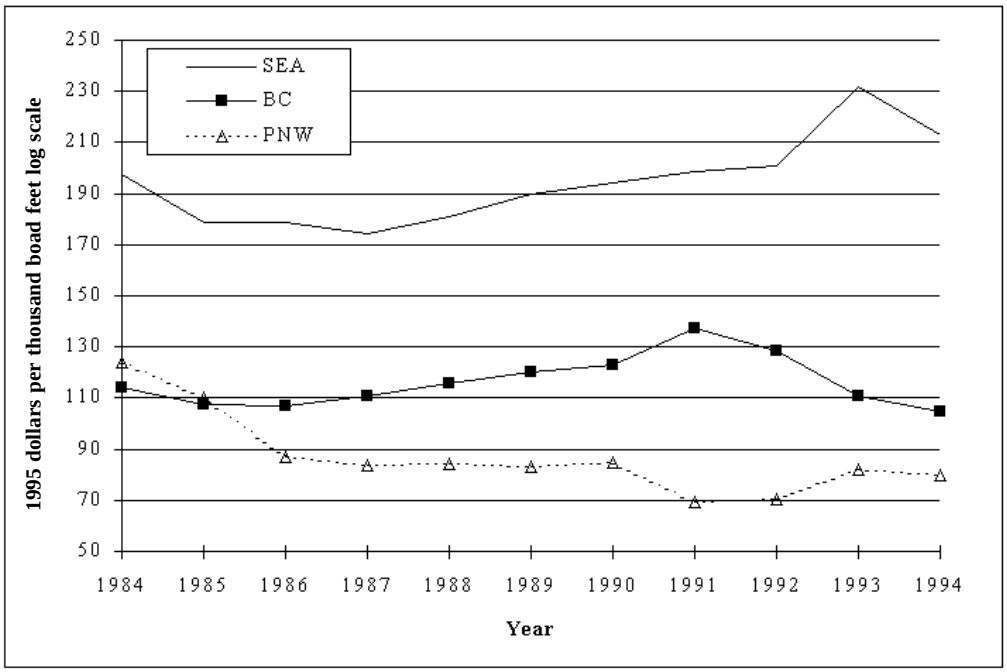

Figure 3—Lumber manufacturing costs in southeast Alaska, the Pacific Northwest, and British Columbia (from USDA Forest Service, Alaska Region, timber sale appraisal data [see footnote 1]; RISI 1996).

The trends in these series are also similar to trends for logging costs. Declining costs in the Pacific Northwest are commonly ascribed to closures of inefficient mills over the last few decades. This occurred in the early to mid 1980s because of a demand-driven recession in the wood products industries, and again in the early 1990s because of a supply contraction from expanded forest conservation. Costs for southeast Alaska, on the other hand, have been increasing at an average 3-percent real growth rate per year over the period shown. Data from previous years, however, indicate that the early 1980s saw a sharp decline in processing costs. (Because of a lack of comparability and other statistical problems, these earlier data are not displayed here). The 3-percent real growth figure, therefore, may be the partial result of the endpoints chosen for analysis and not of longer term trends. Declining log quality and piece size resulting in increased processing and handling costs also may be partly responsible for this trend. Although British Columbia logging costs are similar to those in southeast Alaska, manufacturing costs for British Columbia seem to be closely associated with those of the Pacific Northwest in both levels and trends. This is not surprising given British Columbia's position as a major and highly competitive producer of sawn wood for export markets both in the United States and throughout Asia. Although productivity in the British Columbia logging sector largely will be determined by the physical characteristics of the resource, costs in the sawmilling sector will reflect the efficiency gains needed to successfully compete in global commodity markets.

Factor Costs and Intensity in the Sawmilling Sector

Table 4 summarizes labor inputs in the sawmilling sector. The sources and derivations are similar to those for the logging sector shown in table 3. Again, unit labor costs in southeast Alaska are considerably higher (49 percent higher, on average) than those in the Pacific Northwest. This is due to the combination of higher per-unit labor inputs and higher hourly wages. Although higher factor use in the logging sector is easily explained by the more arduous physical conditions found in southeast Alaska, the

Table 4—Labor inputs in the sawmilling sector, Alaska, Oregon, and Washington (1987-94)

Labor inputs by region	Year								Average	Yearly growth
	1987	1988	1989	1990	1991	1992	1993	1994		
	Hours									*Percent*
Sawmill production (hours per Mbf lt):[a]										
Alaska	3.97	8.81	4.21	5.48	6.89	5.96	7.75	5.25	6.04	3.10
Pacific Northwest	4.54	4.67	4.65	4.78	4.8	4.88	5.19	4.76	4.78	1.20
Difference (percent)	-13	89	-9	15	43	22	49	10	26	—
	Dollars									
Sawmill production wage (1995 $ per hour):										
Alaska	13.35	14.75	13.76	14.28	14.61	17.21	16.02	17.74	15.21	3.80
Pacific Northwest	13.13	12.76	12.69	12.82	12.98	12.92	13.16	13.57	13.01	.50
Difference (percent)	2	16	8	11	13	33	22	31	17	—
	Dollars									
Unit labor cost (1995 $ per Mbf lt):[a]										
Alaska	52.97	130	57.96	78.19	100.59	102.58	124.15	93.07	92.44	7.00
Pacific Northwest	59.64	59.56	59.06	61.26	62.32	63.01	68.28	64.55	62.21	1.70
Difference (percent)	-11	118	-2	28	61	63	82	44	49	—
Difference	-6.66	70.45	-1.1	16.93	38.27	39.56	55.88	28.52	30.23	—

[a] MBF lt = thousand board feet lumber tally.
Source: U.S. Bureau of the Census, Annual Survey of Manufactures (1985-94).

same argument cannot be made for the sawmilling sector. The relatively low score on labor productivity in sawmilling for southeast Alaska is somewhat surprising given the lack of kiln drying and other finished lumber processing in the region, activities which would tend to raise the number of production hours per Mbf in lumber manufacture.

There are several possible explanations for the relatively higher costs of labor for sawmilling in Alaska than in the Pacific Northwest. First and foremost, Pacific Northwest mills are noted for their high degree of mechanization, and, with a large proportion of their activity devoted to the production of standardized dimension lumber, they are likely to benefit from efficiencies and economies of large scale not obtainable in southeast Alaska. Secondly, though adequate figures for fixed capital accumulation are difficult to come by, it is commonly recognized that the capital stock in southeast Alaska is relatively old and poor in quality. Mills in southeast Alaska commonly utilize less expensive and older equipment, which results in lower labor productivity. Thirdly, southeast Alaska mills have been operating well below full capacity throughout the period included in this analysis. This underutilization of installed capacity may have been mirrored by an underutilization of labor resources, with mills hiring more workers per Mbf than would be necessary at optimal capacity utilization.

Many of the arguments relevant to the cost of other factors in the logging sector also apply in the sawmilling sector. With the exception of capital costs, mills in Alaska will face higher prices for goods and services in line with the higher prices faced by all firms operating in the region. As with labor, the absence of large-scale economies will reduce

the productivity of capital investments and other inputs. Also, although the link between physical resource characteristics and the quantity of inputs needed is not as direct as in the logging sector, the remote location mills in the region will necessitate certain inputs, particularly in the area of transportation, not needed in the Pacific Northwest. Consequently, both the unit cost of nonlabor inputs and the quantity needed will be higher in southeast Alaska.

In general, both the trends and levels shown in table 4 are consistent with the data shown in the previous section on total sawmilling costs (fig. 3): southeast Alaska levels are significantly higher than those in the Pacific Northwest, and the difference is increasing over time. In contrast to declines in the total cost data for the Pacific Northwest, per-unit labor cost estimates for the Pacific Northwest show an increasing trend. This constitutes somewhat of an anomaly in the data, but, as with labor costs in the logging sector, the trend estimates presented here are not robust. Moreover, the Pacific Northwest, especially the state of Washington, has experienced rapid increases in secondary manufacturing of wood products in the last decade (Robertson and Lippke 1996). This will be reflected in higher labor inputs per Mbf and thereby higher costs (note that increased production hours per Mbf account for most of the increase in costs in the Pacific Northwest shown in table 4). Because of survey procedures, the cost estimates shown in figure 3 are less apt to include secondary manufacturing activity and thereby register this shift in industry structure in the Pacific Northwest.

Log Conversion Efficiency and Overrun

As with labor inputs, efficiency in the conversion of log inputs to lumber is an important indicator of competitive advantage in lumber manufacture. High conversion rates will minimize log inputs and the costs associated with them, and will thus denote an efficient use of both the forest resource (as embodied in stumpage rates) and the labor and other inputs needed to harvest and deliver logs to the mill. “Overrun” is a measure of the amount of lumber (denoted in lumber tally, or Mbf lt), that can be produced from a unit of log input (log scale, or Mbf ls). Brooks and Haynes (1997) cite an estimated overrun of 1.22 for southeast Alaska in 1994. In contrast, the 1994 Forest Service estimate for the Pacific Northwest is 1.7.[8] Resource Information Systems Inc., a private consultant firm, has estimated the Pacific Northwest west-side overrun at 2.03, though they do not claim that this represents an unbiased sample (RISI 1996). The smaller Forest Service Pacific Northwest estimate of 1.7 is about 35 percent higher than that for southeast Alaska, thereby indicating that, even with equivalent delivered log costs, southeast Alaska mills would incur considerably higher costs for their log inputs. Overrun estimates for British Columbia are currently not available, but it is commonly assumed that British Columbia conversion efficiency is somewhere in between the Pacific Northwest and south Alaska, and most likely closer to the former than the latter.

Various factors will determine log conversion efficiency. Species, log diameters and grades, and the amount of log defect all are important determinants that are beyond the control of the local sawmilling sector. Other, less tangible, factors such as the local pool of labor skills and accepted local business practices also may affect conversion efficiency. Mill technology, however, is often a more important determinant and is directly dependent on the investment and production decisions of mill operators. Choice of end product is likewise largely dependent on producer decisions. Taking independent factors such as labor skills and forest characteristics as a given, there is still good reason why producers may decide not to maximize log-conversion efficiency. In regions like

[8] Personal communication. 1996. Darious Adams, professor, Oregon State University, Corvallis, OR 97331.

southeast Alaska where manufacturing costs (as opposed to delivered log costs) constitute a much higher proportion of the total cost of lumber production incentives to minimize the cost of log inputs may be relatively weak, especially if such moves would entail substantial investments of new capital. Likewise, where relatively large profits are made on a small proportion of the log volume (high-grade spruce and cedar) but the bulk of material (lower grade hemlock) presents little profit potential even when delivered wood cost are excluded from the calculation, incentives to economize on inputs of this lower grade material will be minimal. Here, labor and capital are the high-cost factors, and their use will be minimized relative to that of log inputs.

The above arguments do not explicitly consider the role of wood chips in the sawmill product output mix. Pulp production, however, played a dominant role in the timber economy of the region over the period examined in this report. Consequently, sawmill overrun rates, as well as overall productivity, may have been substantially impacted by the need to maintain a steady supply of mill residue to augment wood fiber supply for the pulp mills. Vertical integration of lumber and pulp manufacturing facilities increases the possibility that this is the case. More generally, the ability to enhance profits through the sale or use of wood chips and other mill residue will alter sawmill behavior and the relation between factor inputs and product outputs. And finally, the ability to legally (and profitably) export certain species in raw log form may affect the behavior of a mill in situations where it has this option. Hence, the low conversions efficiencies of the southeast Alaska sawmilling sector is the likely result of various contributing factors, many of which may make good sense given the product mix and economic conditions prevailing in the region.

Pond Log Values and British Columbia Log Market Prices

Another approach to estimating relative lumber production costs can be made through the comparison of southeast Alaska pond log values and British Columbia log prices. Pond log values are derived by subtracting manufacturing costs from final product prices (FOB mill) as reported for Alaska in the sale appraisal process. Assuming perfect competition in the British Columbia log market, log prices should represent a similar measure, with mills bidding up prices until all profits (that is, revenues over and above production costs and a normal rate of return on investment) are dissipated. A comparison of southeast Alaska pond log values and British Columbia log market prices is shown in figure 4. In terms of both absolute levels and changes over time, prices in the two regions are remarkably similar. If we assume that end-product prices are about equivalent across regions, the implication is that processing costs are also about equivalent in Alaska and British Columbia, or that lumber production is considerably more profitable in British Columbia. When considering the similarity between estimated harvest costs in the two regions and the large discrepancy between sawmilling costs (see previous sections), it seems that the latter argument, that British Columbia mills are more profitable, is the more likely of the two. The lower production costs of British Columbia lumber producers are not reflected in higher log prices. This, in turn, implies a partial break in the link between residual value and prices of intermediate products, with log prices in British Columbia being largely determined by harvest cost and stumpage prices rather than final product price net of mill costs. Once again, however, the caveat concerning different macroeconomic environments in Canada and the United States applies.

Total Costs

By combining estimates of harvest costs with those for sawmilling, we can derive an estimate of the total cost of producing a unit of lumber net of stumpage costs. This estimate is shown in figure 5 for the three regions, and represents the sum of the estimates presented above. This measure, however, is an aggregate of various species and

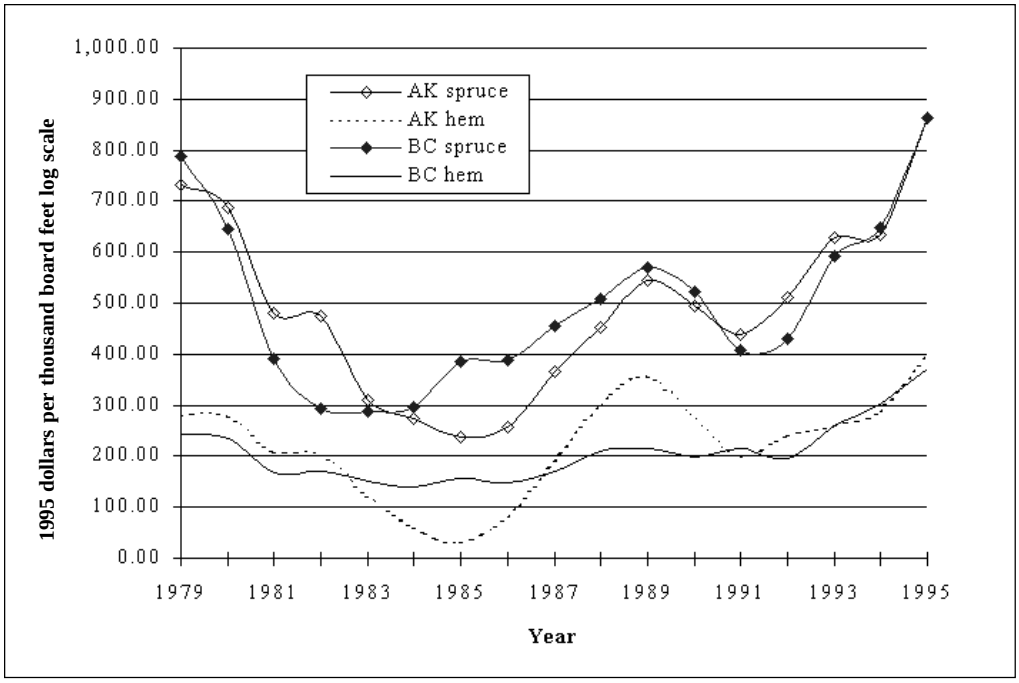

Figure 4—Log values in southeast Alaska and British Columbia (from USDA Forest Service, Alaska Region timber sale appraisal data [see footnote 1]; British Columbia Council of Forest Industies (see footnote 3).

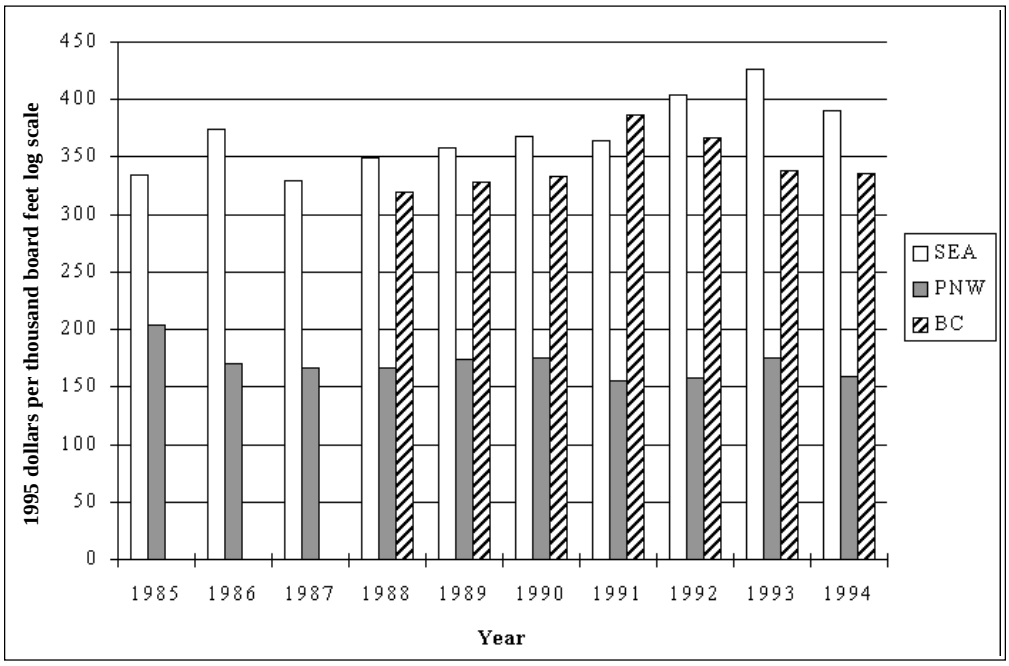

Figure 5—Total production costs (logging + lumber) (from USDA Forest Service, Alaska Region, timber sale appraisal data [see footnote 1]; RISI 1996).

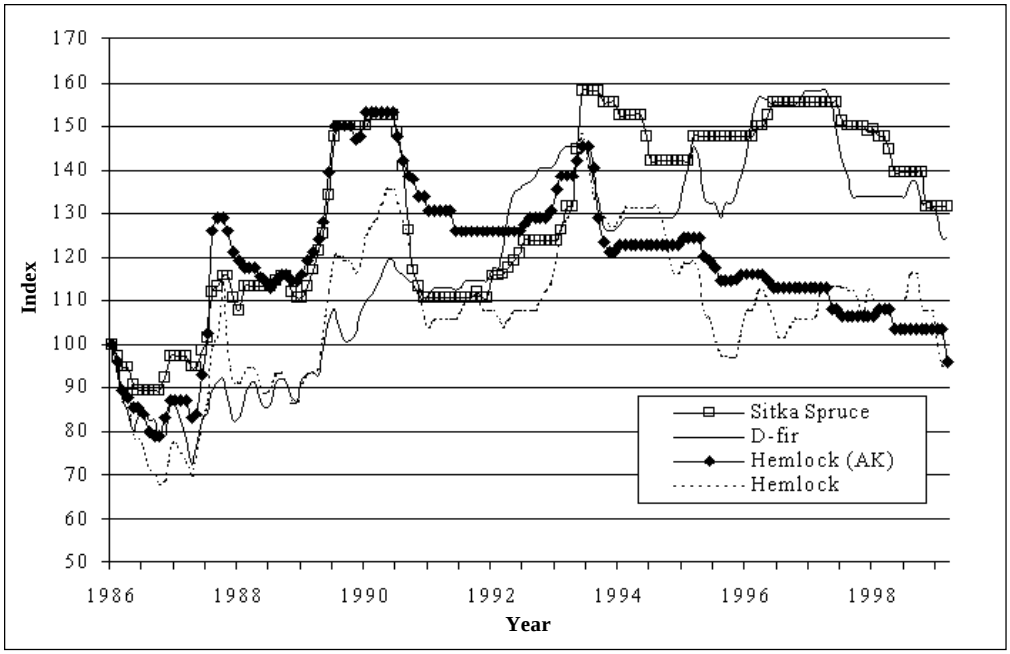

Figure 6—Japan wholesale log prices (yen price index, January 1986 = 100) (Japan Lumber Reports 1945-94).

products and the results cannot be directly extended to particular cases without careful consideration. Southeast Alaska is the highest cost producer in most of the years. Primarily because of its higher harvest costs, British Columbia is the high cost producer in 1991 and is close to southeast Alaska in other years until 1993, when trends for the two regions diverge. Throughout the period shown, costs for southeast Alaska generally are increasing, which is in contrast with stable to declining costs in the Pacific Northwest and a rising and then declining trend in British Columbia.

End Markets

End markets will ultimately determine the value of southeast Alaska products relative to that of its competitors. The following analysis concentrates on Japan's market for North American softwood logs and sawn wood. The strategy here is to analyze product prices to ascertain the relative position of southeast Alaska products in this market. Japan traditionally has been the principal market for southeast Alaska logs and lumber and the largest export market for Pacific Northwest and British Columbia products if cross border trade between Canada and the United States is excluded. As such, Japan's market is the most logical place to compare relative prices and products from the three producing regions. However, with the collapse of Japan's prices for higher grade logs and lumber in the last few years, southeast Alaska producers have devoted an increasing share of their production to supplying U.S. consumers in the lower 48 states.

Figure 6 displays yen-based price indexes for major North American log export species in Japan's market. The use of an index was chosen because the price data were not comparable among different species (different sizes and grades were used for each). Before 1993, western hemlock, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and Sitka spruce log prices fluctuate in a broadly similar fashion. During this period, it

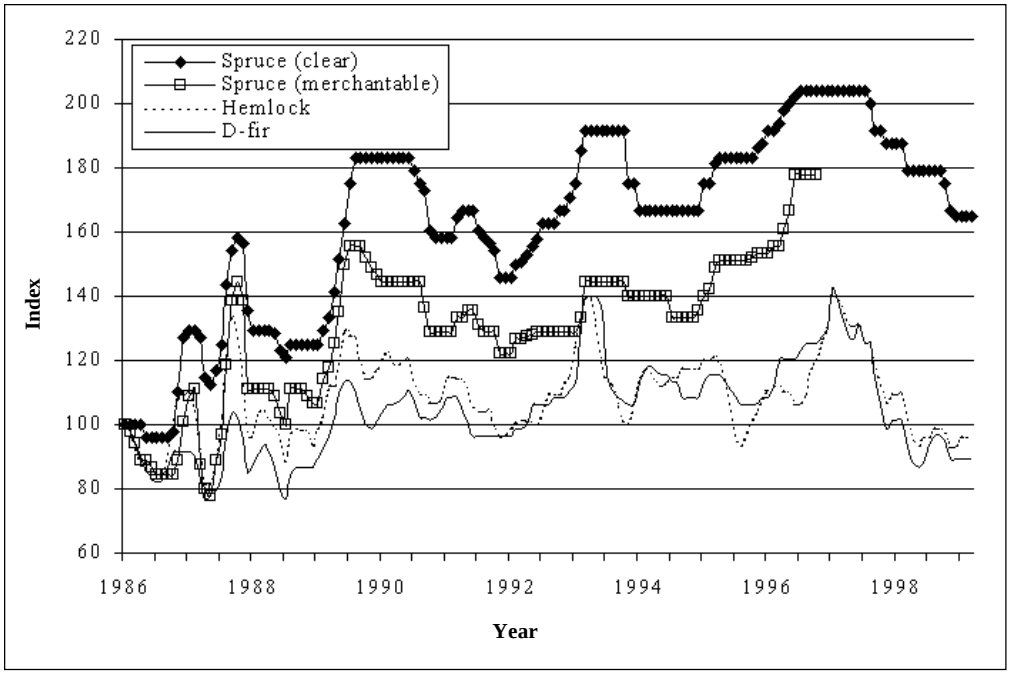

Figure 7—Japan wholesale lumber prices (yen price index, January 1986 = 100) (Japan Lumber Reports 1945-94).

seems that geographic origin rather than species is the primary factor in the correlation of price changes, with the two Alaska species moving much in tandem and (non-Alaska) hemlock and Douglas-fir likewise following each other closely.

After 1993, the indexes begin to diverge, with Sitka spruce prices stabilizing at a high level, Douglas-fir prices rising through rapid fluctuations, and prices for western hemlock logs (from Alaska and other sources) showing declines. This provides a partial indication of the market position of southeast Alaska products, where Sitka spruce occupies a high-quality niche position relative to hemlock. Western hemlock is imported by Japan in larger volumes from both the Pacific Northwest and British Columbia than from southeast Alaska, and it is more prone to substitution from other species, especially at the lower end of its grade distribution. This conclusion is further borne out in figure 8, which displays comparable indexes for Sitka spruce, Douglas-fir, and western hemlock lumber. Here Sitka spruce clearly emerges as a separate product subject to the same general fluctuations over time but displaying a much greater overall trend in price increase. This, in turn, indicates an important component of the potential competitive advantage of southeast Alaska: its ability to fill this lucrative and relatively unique market niche. Although in direct competition with spruce production in British Columbia, Sitka spruce production in southeast Alaska comprises most of the North American total, and the region likely enjoys a certain degree of market power, which may counterbalance local diseconomies in logging and sawmilling.

Southeast Alaska hemlock, on the other hand, supplies a broader commodity market and faces greater competition from other producers and species. Given the relatively low volumes supplied by Alaska, it will be a true price taker in this market. Consequently, future prospects for hemlock production in southeast Alaska will largely depend on developments external to the region, including substitution by softwood species from

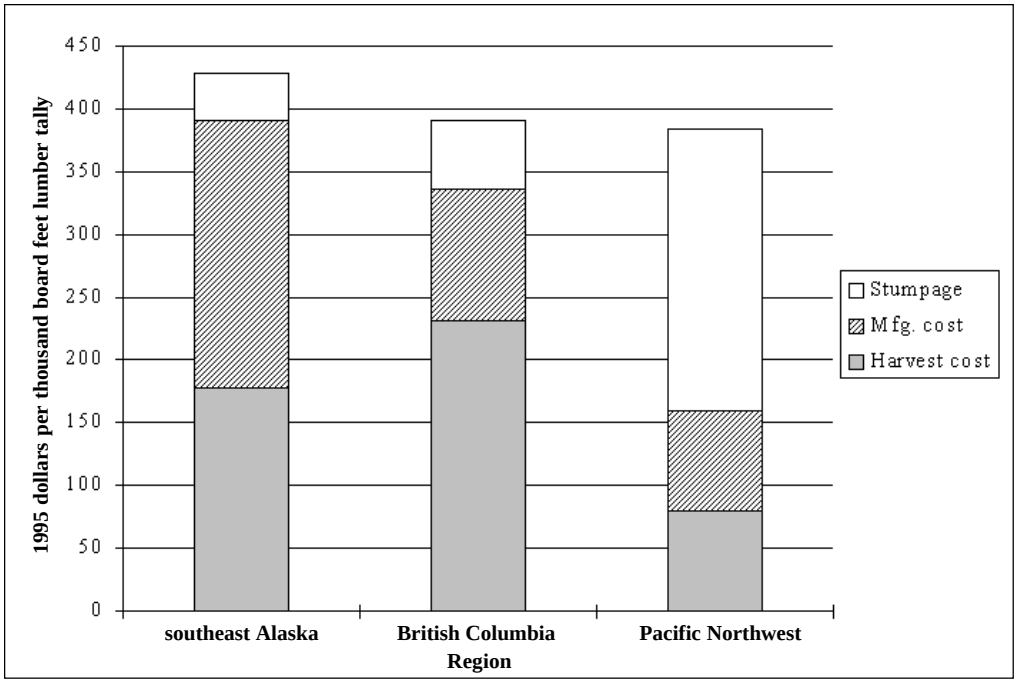

Figure 8—Total lumber production costs (with stumpage), 1994 (from USDA Forest Service, Alaska Region timber sale appraisal data [see footnote 1]; RISI 1996).

the Russian far east, Northern Europe, and the conifer plantations in the Southern Hemisphere; the expanding market share of engineered or fiber-based products; and a general trend toward the use of lower valued species in higher valued applications. Increasingly, the cost and quality of "value-added" inputs (capital and labor), and not the characteristics of raw log inputs, will determine the success of wood products manufacturers supplying these commodity markets. Consequently, hemlock resource in southeast Alaska may provide a necessary condition for wood products commodity manufacture and export, but the region will have to compete on the basis of other inputs.

Although we have given little attention in this report to log exports originating on private lands in southeast Alaska, these exports constitute an important source of competition for southeast Alaska processed wood products, especially for higher grade spruce (Flora and others 1992). Evidence for this can be found in the close correlation between the fluctuations in Sitka spruce log and lumber prices in Japan shown in figures 6 and 7. The likely conclusion here is that spruce lumber is supplying much the same end markets whether it is processed in southeast Alaska or in Japan. Given the supposed market power of the region in Sitka spruce production, anticipated declines in private log production and exports could result in higher prices for domestically produced lumber. For lower valued log grades and species (primarily hemlock), the same argument does not hold. This is not surprising given the small share of southeast Alaska products in these markets; declines in hemlock log exports from private lands will not be sufficiently large to significantly impact market prices for hemlock lumber.

Stumpage Prices and Residual Values

Under the assumption of perfect competition in stumpage markets, stumpage prices will be about equal to market prices net of all production and delivery costs.[9] Ideally, competition among stumpage purchasers will result in cost minimization and zero "economic" profits (in other words, returns over and above a competitive return on invested capital) in the processing and delivery sectors. Consequently, economic rents will be maximized and concentrated in the stumpage price. To the extent that this holds, stumpage prices will be directly linked to residual value. Given a definition of competitiveness that relies on the cost of producing a good relative to its final market, the residual value, and thus the stumpage price, will constitute the single most indicative measure of regional competitive advantage in log production.

Depending on the proportion of local timber further processed in the region, stumpage prices also may provide an indication of competitiveness in the wood-processing sectors. This is especially true when, as is the case in each of the regions considered in this report, a significant proportion of harvest is barred from export in raw log form. Competition from log exporters is thus eliminated from stumpage markets for export constrained timber, and prices will reflect only the demand (and hence profitability) of local processors. Here, high stumpage prices will indicate local industries whose costs are well below the final value they generate, and conversely, low stumpage prices will indicate an industry operating at the margin of profitability. Note that if timber is not locally scarce, then the profitability of local processors will signal increased production either through additional investments by existing firms or the entry of new firms. Eventually, economic profits will be eliminated either through wage increases for relatively scarce inputs, or final market price decreases because of the increased product supply. This is the market mechanism mentioned previously, which relates competitive advantage to revealed comparative advantage via the market equilibrium process. For the regions and tree species considered in this report, however, timber is a scarce resource, and positive stumpage prices apply.

The relation between stumpage values and production costs is shown in figure 8. Harvest and manufacturing costs are the same as those cited previously in this report, except in this case, harvest costs are converted to a thousand board feet lumber tally basis. Stumpage prices are the prices received at the time of harvest (actually a "cut price"), also expressed in terms of thousand board feet lumber tally. For southeast Alaska, these prices are for federal timber, and in the Pacific Northwest, they are for federal timber in California, Oregon, and Washington west of the Cascade crest. British Columbia prices are for timber harvested on crown lands in coastal British Columbia (as reported by RISI 1996). Total production costs are relatively similar for all regions, but the distribution of these costs across the different categories is great. Following the arguments presented above, the assumption here is that high production costs in southeast Alaska and British Columbia lead to low stumpage values, and low production costs in the Pacific Northwest lead to high stumpage prices. The data presented in figure 4 represents a simplification, which aggregates across a wide range

[9] Because stumpage sales often occur a year or more before the anticipated time of harvest, stumpage prices will incorporate future expectations and attitudes to risk on the part of buyers in addition to current market conditions and firm profitability. Also, policies regarding stumpage price adjustments in line with market price fluctuations along with other peculiarities of specific market arrangements also will influence bid and realized prices at stumpage auctions.

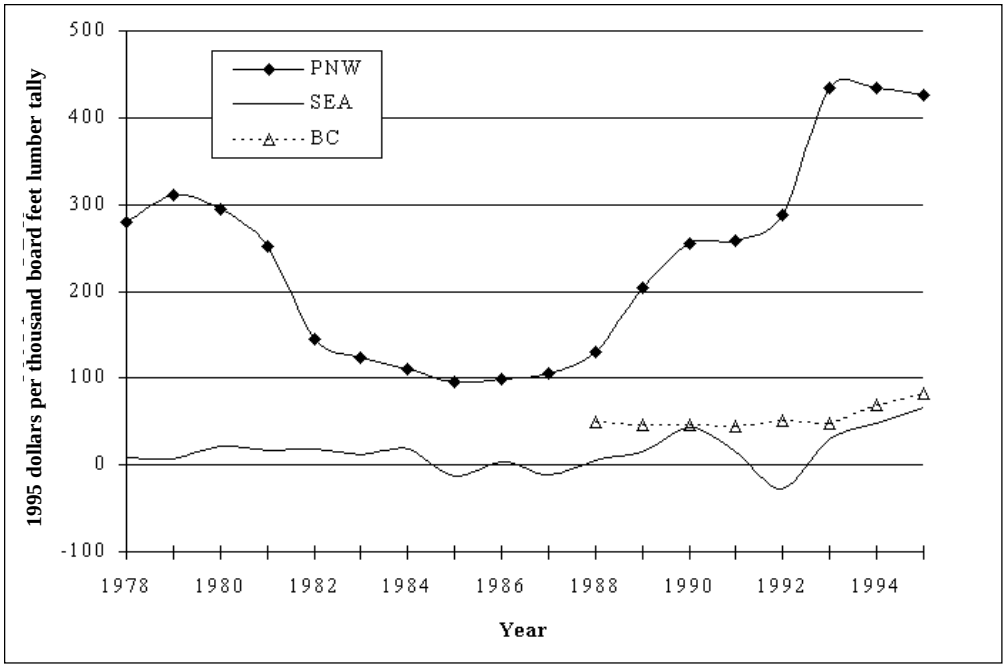

Figure 9—Cut prices for southeast Alaska, Pacific Northwest, and British Columbia national forests, all species (from USDA Forest Service and British Columbia Ministry of Forest as reported in Warren 1999)

of species and products. Likewise, especially in the case of the Pacific Northwest and British Columbia, the various figures reported in figure 4 do not come from the same source and may be only loosely comparable. Nonetheless, these numbers provide a clear depiction of the different aggregate costs in the competing regions, and the relation among these costs, final market values, and stumpage prices.

With the highest total production cost of the three regions and a substantially lower stumpage value, the marginal position of southeast Alaska as a high cost producer is evident. As stumpage price cannot fall below zero (in theory at least), the profitability of the sector will be highly susceptible to relatively small variations in end-product prices. British Columbia has somewhat lower production costs, but its stumpage values are only slightly higher than those in southeast Alaska. The explanation for this discrepancy may lie in differing end products (that is, if British Columbia generally produces lower valued lumber) or in differences in reporting procedures, firm profitability, and tax structures. The Pacific Northwest demonstrates both the lowest production costs and by far the highest realized stumpage value of the three regions. Here, efficiency in production allows for substantially increased returns to stumpage. To the extent that fluctuations in end-product prices are directly transmitted to stumpage, the Pacific Northwest can sustain large declines in end-product prices without a loss of profitability for the sector.

Historical values in cut prices for the Tongass National Forest, the Pacific Northwest, and British Columbia are shown in figure 9. Pacific Northwest prices are the harvest prices reported for national forests in the Pacific Northwest Region, and logs from these harvests are restricted from raw log export. Because log exports also are restricted for British Columbia and the Tongass National Forest, all the harvest prices reported here will be for export-restricted logs and will thus incorporate competitiveness factors in the

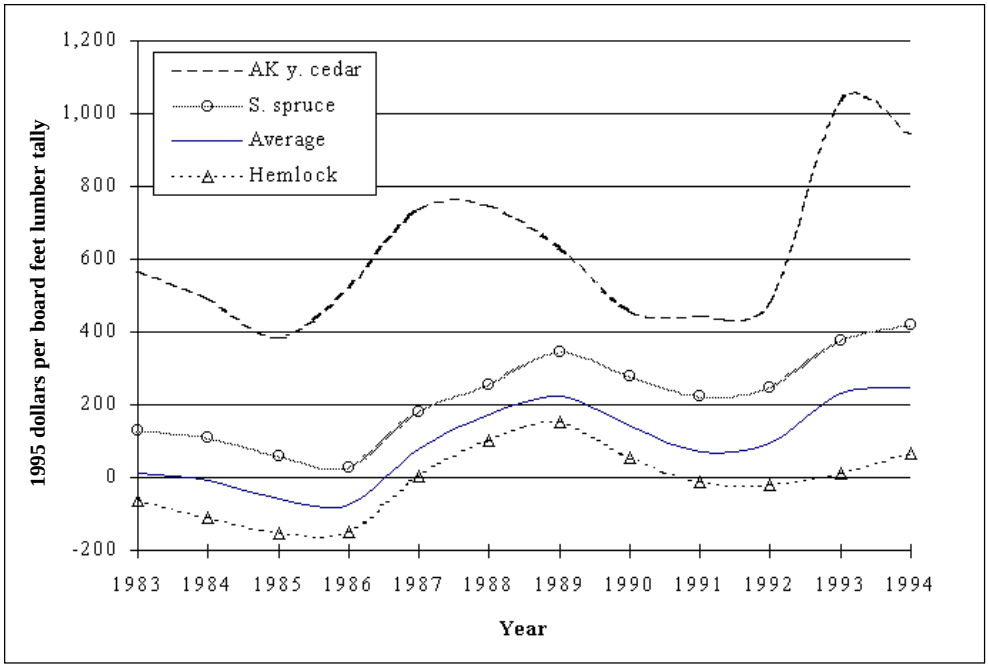

Figure 10—Southeast Alaska average residual value by species (sawtimber and pulpwood) (from USDA Forest Service, Alaska Region, timber sale appraisal data [see footnote 1]).

sawmilling as well as logging industries. As is true with the 1994 data shown in figure 4, figure 9 displays the marginal character of southeast Alaska operations relative to the Pacific Northwest and supports the conclusion that the Pacific Northwest generates a much greater residual value per thousand broad feet harvested and processed. Perhaps surprisingly, British Columbia cut prices are only slightly higher than those for southeast Alaska, thus reflecting the comparable harvest costs prevailing in that region, but also perhaps different timber sale procedures and the failure of British Columbia processors to incorporate profits from their relatively efficient sawmilling operations into their stumpage bids. Cut prices reported for southeast Alaska are confounded by retroactive rate redeterminations and other factors peculiar to the region, thereby resulting in negative prices in some years.

Much of the preceding discussion has been based on regional aggregates across species and log grades. More detailed data generated in the sale appraisal process allows for an analysis of residual values on a species-by-species basis for the Tongass National Forest (fig. 10), but comparable analyses are presently not possible for the other regions. These values were calculated by subtracting species-specific manufacturing costs from selling values (as reported in the midmarket analysis in the Alaska Region sale appraisal process) and then further subtracting average harvest costs calculated from the independent sale appraisals (see above). These data display a strong differentiation in value by species. Hemlock and spruce generally move in tandem and demonstrate an overall upward trend but marked cyclic fluctuations. Hemlock is the lowest valued species with estimated residual values dipping below zero in the mid-1980s and early 1990s. These fluctuations roughly correspond to price movements in the international pulp market (note that utility logs and a proportion of low-grade saw logs are assumed to be used as pulp and are appraised accordingly). Sitka spruce demonstrates substantially higher residual values, obtaining levels between $200 and

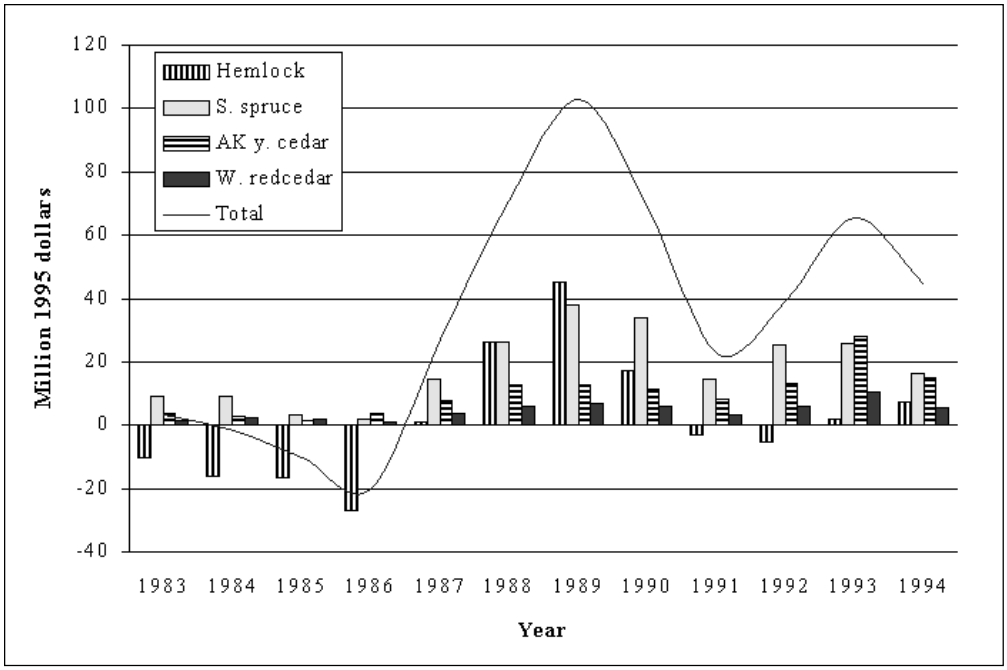

Figure 11—Southeast Alaska total estimated residual value by species (from USDA Forest Service, Alaska Region, timber sale appraisal data [see footnote 1]).

$400 per thousand board feet throughout the 1990s and late 1980s. This estimate is for all log grades, and residual value estimates for better spruce grades would be considerably higher. Alaska yellow cedar generates extremely high residual values owing to its high selling value and low manufacturing price (essentially a port delivery cost as Alaska yellow cedar is exempt from log export restrictions and is exported almost exclusively in raw log form). Because of the predominance of hemlock and spruce in the volume mix, the volume weighted average closely follows the hemlock price but is higher because of the higher price of other species.

By multiplying the per thousand board feet residual shown in figure 10 by total harvest volume for each species, an estimate of total residual value generated in southeast Alaska by individual species can be calculated (fig. 11). Again, the high proportion of hemlock volumes means that total residual values will be sensitive to relatively small fluctuations in the price of hemlock. In half of the years, the contribution of hemlock to residual value is negative, and only in 1988 and 1999 does it provide a substantial positive contribution to total value. Also, given the extremely large residual values associated with Alaska yellow cedar and, to a lesser extent, western redcedar, the total residual value generated by these species accounts for well over half of the Tongass National Forest total in the last few years. This highlights the economic importance of Alaska yellow cedar and western redcedar, species that often garner considerably less attention owing to their relatively small volumes.

Overall positive trends for the residual values shown in figures 10 and 11 indicate increasing profitability for the sector as a whole. Much of this, however, is due to the fact that in the early 1980s, a major global slump occurred in demand for wood products followed by a recovery and then further upward pressure on North American softwood prices because of harvest restraints in the Pacific Northwest. A sharp decline in prices for most grades and species in southeast Alaska has occurred in the latter half of the 1990s.

Taken together, the residual value estimates for individual species indicates that the region is capable of generating significant value in certain species but that the profitability of the timber sector at large will be extremely vulnerable to market price fluctuations in hemlock. This result is based on species averages across all log grades. If log grades also were considered, price fluctuations for lower grades of both spruce and hemlock likely also would prove to be a major determinant in sector profitability. As shown in the earlier section on forest resource characteristics, most of the material harvested from the Tongass is in mid to lower grades of spruce and, especially, hemlock. Because of the heterogeneous nature of southeast Alaska forest stands and specific regulations designed to limit high-grading on federal lands, the ability of the sector to adjust the mix of grades and species to different market conditions is limited. Consequently, potential profits from the sale of higher valued species and grades, particularly cedar, often may be sacrificed to support the harvest and processing of lower quality material.

Comparative and Competitive Advantage Revisited

How do the data and arguments presented previously relate to the concepts of comparative and competitive advantage? The first conclusion that can be made is that southeast Alaska is at a competitive disadvantage in the provision of labor as an input in the production process. This argument is likely true for capital (and other nontimber inputs) as well. If this is the case, then the region has a competitive disadvantage in value-added processing as a whole, as labor and capital alone comprise the value-added component of any good. From the standpoint of comparative advantage, this means that labor and capital are scarce relative to the supply of other inputs, notably timber. Given recent layoffs and mill closures, it is hard to argue that labor shortages characterize the current situation in the southeast Alaska timber sector. Nonetheless, it must be remembered that comparative advantage is a long-term equilibrium concept, and short-term fluctuations in labor markets do not apply. In general, the high wages paid for labor (and other inputs) in southeast Alaska reflect the premium needed to attract and keep workers in the region. From an economic standpoint, this premium is synonymous with relative labor scarcity—there are relatively more jobs to do than qualified workers to do them, and producers will consequently bid up the price of labor.

In spite of this competitive (and comparative) disadvantage, southeast Alaska is able to profitably produce certain types of wood products. This is because of the scarcity rents generated by the better species and log grades of the region. Hence, the advantage of the region can be seen as lying in its ability to supply these scarce raw materials (logs) and not in providing value-added inputs in combination with them. This assertion should, in turn, be revealed in the behavior of local firms. Economic theory (as well as common sense) predicts that firms faced with a competitive disadvantage in processing will provide the minimum of processing necessary before export. In doing so, they will minimize the losses incurred in their noncompetitive processing sector and thus maximize profits. The fact that virtually all private harvests of suitable quality in the region are exported in raw log form bears this prediction out, as does the fact that local mills have been wholly unsuccessful at bidding private logs away from the export market. Although data on factor use in the sawmilling sector presented previously do not directly indicate that mills are likewise minimizing inputs, the lack of lumber finishing and secondary manufacturing facilities in the region further suggests a comparative disadvantage in processing.

Certain determinants of comparative and competitive advantage do not change over time. Location is one such factor. The remoteness, climate, and difficult topography of southeast Alaska are major factors that impact both the price and productivity of labor and, by extension, other nontimber inputs. Moreover, although the region is considerably closer to Japan and other export markets in northern Asia, this has not

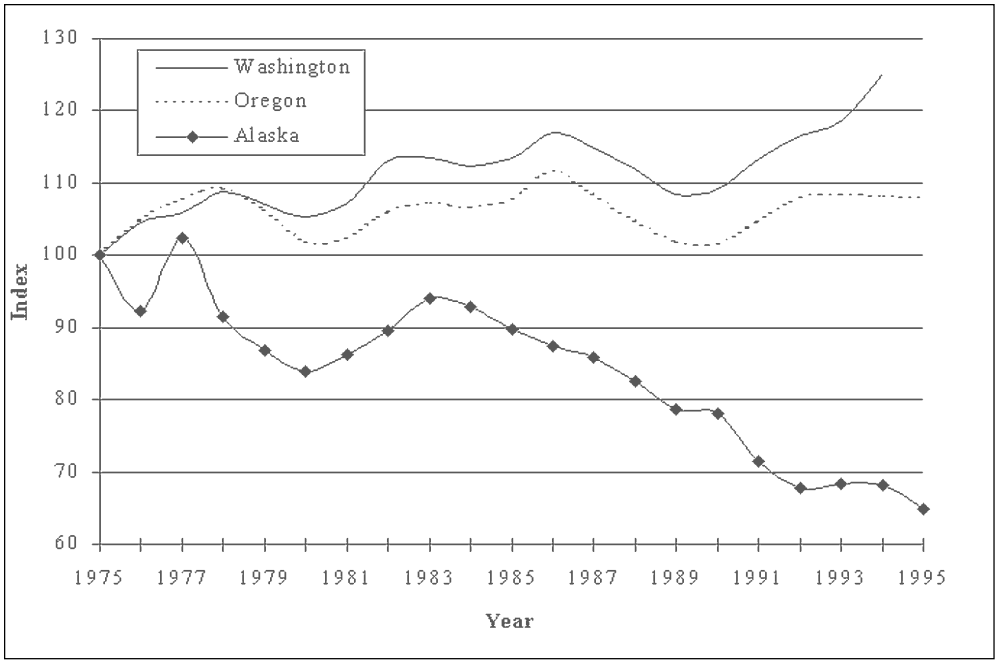

Figure 12—Real manufacturing wages for Alaska and the Pacific Northwest (index, 1975 = 100) (U.S. Bureau of the Census, Annual Survey of Manufactures [1985-94]).

translated into a cost advantage in trans-Pacific shipping owing to diseconomies associated with the smaller volume of trade, weather conditions, and the lack of backhaul opportunities (Wisdom 1990).

Comparative advantage, however, is not a static concept, and the relative advantage of nations and regions will be in constant flux. Alaska is no exception to this rule. Prices for most goods and services are considerably higher in Alaska because of several factors, with the absence of economies of scale and transportation costs being chief among them. As for wages, there is an added factor related to the need to provide wage premiums over and above cost of living adjustments to induce workers to move to the state in spite of a harsher climate, remoteness, and other perceived disamenities (Greenwood and others 1991). Recent years, however, have seen a steady reduction in many of these factors. Growing population has allowed for increasing economies of scale in transportation, retail and services, and other sectors, and the positive amenities of life in Alaska have increasingly come to be recognized by local residents and potential immigrants.

Although the data specific to the wood products sector presented in this report give little indication of relative trends in factor input prices, broader measures of the Alaska economy clearly indicate a steady reduction in prices relative to the rest of the United States. Figure 12 shows real wage indexes in the manufacturing sector for Alaska, Oregon, and Washington. Although the Pacific Northwest states demonstrate a similar increasing trend, Alaska's index shows a dramatic decline, particularly in the 1983-92 period during which the index fell by 28 percent. Current manufacturing wages in Alaska are about equivalent to those in the Pacific Northwest, and these developments likely will be mirrored in the wood products sector of southeast Alaska in the coming years. Ideally, a regional producer price index would be the best way to gauge changes in factor input prices in Alaska relative to those in other regions. Such indexes are not

available at the state level. Consumer price indexes (CPI), however, are available for certain urban areas, Anchorage Alaska, among them. In the last decade or so, the Anchorage CPI has fallen slightly more than 10 percent relative to the U.S. average index. This is equivalent to about a 10-percent decline in absolute prices for the Anchorage area. Prices in Alaska are still considerably higher than elsewhere, but they are falling in relative terms.

The data on falling relative prices in Alaska should be treated with some caution. Because it is a composite of wages in all manufacturing industries, the wage index may reflect changes in industry composition (increasing shares in hi-tech manufacturing in the Pacific Northwest and fish processing in Alaska, for example) as well as actual declines in real wages within a given industry. Likewise, the Anchorage CPI may not be indicative of changes happening in southeast Alaska, as Anchorage is relatively far from the region and is substantially larger and therefore enjoys greater economies of scale. Nevertheless, it is plausible that continued economic growth in southeast Alaska will result in declines in producer prices and that the region will see a gradual but steady increase in its relative advantage in wood products processing. Changes in statewide wages and consumer prices may partially reflect just such a process. Likewise, the desire of residents to continue to live and work in the region should not be discounted. Southeast Alaska is perhaps unique in the number (in per capita terms) of individual entrepreneurs who paln to attempt small-scale wood products manufacturing in the region. The willingness of these owner operators to work long hours for little pay, however, likely does not extend to a willingness to work for lower wages in a large mill or related facility.

Conclusion

The comparative and competitive advantage of southeast Alaska lies in its stocks of high-grade spruce and cedar timber. In terms of log production, it seems that southeast Alaska is competitive with British Columbia, the only other major source of Sitka spruce. Other species, even hemlock, can be profitably harvested given log grades of suitable quality. In all cases, it is the scarcity value of the resource that allows for profitable operations. In sawmilling, the evidence shows that costs in southeast Alaska are significantly higher than those in both the Pacific Northwest and British Columbia. In an open market, southeast Alaska lumber producers would be unable to compete in stumpage and log markets with more efficient mills in other regions. With the prohibition of log exports from federal lands, however, processors are able to charge a portion of their higher costs against the scarcity value of the timber resource, thereby resulting in reduced stumpage prices. This allows the national forest to bear the costs of regional diseconomies in processing. Although this is not efficient in an economic sense, the Tongass National Forest is managed to meet various local and national objectives; as part of the balance among objectives, returns to the Treasury are foregone in favor of opportunities for local employment.

The above arguments have important implications for current efforts to increase value-added manufacturing in the region. In general, efforts to cultivate manufacture of commodity products in direct competition with major producers in other regions will be a challenge. This is especially true for products where value-added inputs, rather than timber scarcity rents, comprise a relatively large proportion of the final product value. The development of niche industries relying primarily on Sitka spruce may be more successful (as evidenced by the music wood and other specialty producers currently operating on Prince of Wales Island). Anticipated declines in private harvests in southeast Alaska and Sitka spruce production in British Columbia may further bolster the chances of success in these ventures. Alaska yellow cedar has commanded extremely

high prices in Japan's market, and southeast Alaska has a near monopoly in its production. These prices could bear increased processing (with diseconomies once again being charged to the stump), but processors must compete with log exports. In the absence of strict export bans, it is doubtful that they can do so successfully in large numbers. In any case, Alaska yellow cedar volumes are not large enough to generate significant employment in manufacturing commodity products. Moreover, attempts to increase processing of this species must be balanced against probable reductions in residual values and thus stumpage prices.

Most of southeast Alaska timber inventory, however, is concentrated in lower valued species and log grades. Successful policies directed to this portion of the resource likely would involve efforts to promote cost minimization and economies of large scale in processing. An alternative would be to reduce or forego processing of this material altogether, thereby allowing the region to concentrate on those areas where it has a demonstrated advantage. This could be obtained either by relaxing those harvest restrictions that prohibit partial harvests (favoring better species and grades) or by relaxing processing requirements for certain lower grades. Such policy changes will have to be evaluated in relation to other forest policy goals in the region and the ecological consequences of alternative harvesting methods. Should declines in wages and the price of other inputs result in changes in the comparative advantage of the region in the long term, then it is likely that increased value-added processing of lower grade materials may evolve on its own accord. Ideally, such an industry would draw on both private and public timber supply in the region.

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Resource selection by coastal wolves reveals the seasonal importance of seral forest and suitable prey habitat

Gretchen H. Roffler[a,*], David P. Gregovich[a], Kristian R. Larson[b]

[a] Alaska Department of Fish and Game, Division of Wildlife Conservation, 802 3rd Street, Douglas, AK 99824, USA
[b] Alaska Department of Fish and Game, Division of Wildlife Conservation, 2030 Sealevel Drive, Suite 205, Ketchikan, AK 99901, USA

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ABSTRACT

Wolves (*Canis lupus*) in Southeast Alaska inhabit temperate rainforests characterized by patchworks of old-growth and harvested forest stands in various stages of regeneration. Investigating wolf space-use patterns in this landscape may yield information on their tolerance of anthropogenic disturbance in forest ecosystems. Furthermore, identifying shifts in habitat selection throughout the year can provide insights into wolves' ability to exploit seasonally available resources. We examined seasonal habitat selection of wolves on Prince of Wales Island, Alaska with respect to forest structure, succession, land cover, topography, road densities and habitat predicted to support Sitka blacked-tailed deer (*Odocoileus hemionus sitkensis*) and salmon (*Onchorynchus* spp.), the primary and a secondary prey species. We used GPS locations from 13 wolves during 2012–2016 to develop resource selection functions (RSFs). Within their home ranges, wolves selected low elevation, flat terrain with open land cover and low-volume old-growth forests across seasons. During fall and winter wolves preferred clearcuts ≤30 years old, but avoided clearcuts > 30 years old and thinned young-growth relative to medium-volume old growth. Habitats with predicted high deer carrying capacities were selected during late summer and fall, and areas close to anadromous streams were important only during summer when salmon were spawning. Areas of high road densities were avoided during denning season and summer, but strongly selected during winter. Our study reveals the potential of coastal wolves to seasonally target prey habitat and adjust to altered landscapes, but successional forests had a limited period of use (< 30 years), thus forestry practices could reduce availability of wolves' preferred habitat.

1. Introduction

Wolves in coastal Southeast Alaska and British Columbia inhabit temperate rainforests distributed across island archipelagos (except for Admiralty, Baranof and Chichagof islands) and a narrow region of the mainland coast separated from the continental interior by mountains and icefields. Coastal wolves are considered distinct from continental populations due to morphological (Goldman, 1944; Nowak, 1983), genetic (Weckworth et al., 2010, 2011; Cronin et al., 2014), and ecological characteristics (Weckworth et al., 2005; Muñoz-Fuentes et al., 2009). Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) constitute the primary prey of coastal wolves throughout most of their naturally fragmented range, in addition to marine resources such as salmon (*Onchorynchus* spp.) and marine mammals (Szepanski et al., 1999; Darimont et al., 2004). This ecosystem has supported wolves for approximately 12,000 years when glacial ice retreated and opened colonization routes from southern Pleistocene refugia (Nowak, 1995). In contemporary times, large-scale industrial logging has transformed forested sections of this landscape into a mosaic of productive old-growth forest and clearcuts in various stages of succession (i.e., young-growth). Intensive industrial-scale logging has occurred since the 1950s, and the resulting forest alteration, habitat fragmentation, and development of a network of roads have raised concerns about the impacts on wildlife populations (Schoen and Kirchhoff, 1988; Cook et al., 2006; Albert and Schoen, 2013).

Temperate rainforests transition through stages of succession post-logging and the consequences to resident wildlife are best understood for deer (Doerr et al., 2005; Hanley et al., 2005; Farmer et al., 2006; Farmer and Kirchhoff, 2007), and affect coastal wolves directly through habitat changes and indirectly through their deer prey. Old-growth forests are heterogeneous in stand age and canopy structure, allowing sufficient light to penetrate to the forest floor and support diverse understory species including shrubs, forbs, and lichens that are important deer forage (Alaback, 1982). Understory shrubs regenerate in young clearcuts (age 0–25–30 years), particularly during summer and mild winters (Alaback, 1984; Farmer and Kirchhoff, 2007; Cole et al., 2010),

* Corresponding author.
E-mail address: gretchen.roffler@alaska.gov (G.H. Roffler).

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but during severe winters, early successional forests lack a canopy capable of intercepting snow (Kirchhoff and Schoen, 1987), allowing shrub burial (White et al., 2009) and increasing energetic costs of deer movement (Parker et al., 1999). Older clearcuts (> 25–30 years) grow into even-aged stands with dense canopies which block sunlight and impede growth of deer forage (Alaback, 1982; Schoen et al., 1988, Farmer and Kirchhoff, 2007). This is also known as the stem-exclusion phase and may last > 100 years (Wallmo and Schoen, 1980; DellaSala et al., 1996). These second-growth forests are unproductive for many old-growth associated wildlife species, and the delayed effects of past timber harvest (termed "succession debt") predicts long-term and large-scale declines of deer, and subsequently wolves (Person, 2001).

Wolves in Southeast Alaska have been a focal point of conservation concerns since the 1990s, with heightened attention to the negative consequences of timber harvest on wolf and deer habitats, and increased access from roads built to support the timber industry resulting in higher wolf harvest by humans (Person et al., 1996, 2001; Swanston et al., 1996; Wolf Technical Committee, 2017). In 1993 and 2011 the U.S. Fish and Wildlife Service (USFWS) was petitioned to list Southeast Alaskan wolves under the Endangered Species Act. The most recent petition outlined specific concerns for wolves on Prince of Wales Island (POW), reflecting increased alarm over the effects of continued old-growth logging, as the most intense logging activity in Southeast Alaska occurs on POW (Albert and Schoen, 2013). After completing status reviews, the USFWS determined that listing was not warranted in 1995, in 1997 (after the finding was remanded), and again in 2015. Despite the recent finding, concerns were raised in the species status assessment about the sustainability of POW wolves due to reductions in habitat capability of deer resulting from timber harvest management (USFWS, 2015; FR 32473, 5 Jan 2016).

The majority of the land in Southeast Alaska is within the Tongass National Forest managed by the U.S. Forest Service (USFS). Recently, the USFS developed habitat and access management recommendations to the Tongass National Forest Land and Resource Management Plan (USFS, 1997; USFS, 2008) to maintain long-term, sustainable wolf populations (Wolf Technical Committee, 2017). The key recommendations relating to habitat included enhancement of the deer populations by increasing forage, maintaining corridors to facilitate movement, and increasing heterogeneity within young-growth forest stands, especially in winter habitats (Wolf Technical Committee, 2017). One management action proposed to accomplish these objectives is treating young-growth forest with thinning, with the intended effects of delaying the development of stem exclusion and hindrance of understory forage growth from shading (Hanley, 2005; Cole et al., 2010). The USFS recently implemented a strategy to transition harvest from old-growth forest to young-growth forest with the goal of establishing ecologically, economically, and socially sustainable management practices (81 FR 88657, 8 Dec 2016). The first large-scale effort towards this transition began on POW in 2017; old-growth logging will constitute the majority of the harvest for the first decade of the transition, followed by an increasing proportion of young growth until reaching nearly 100% by the end of the 16 year period.

Wolves are considered habitat generalists (Mladenoff et al., 1995; Fritts, 2003), able to survive in a broad range of ecological conditions, limited mainly by prey availability and mortality risk (Fuller et al., 2003). Furthermore, wolves demonstrate marked dietary plasticity (Peterson and Ciucci, 2003), which suggests the possibility of weak habitat selection patterns and the potential for resilience despite changing habitat conditions. However, patterns of habitat preference may be revealed at finer scales (within the home range; Ciucci et al., 2003) and may shed light on thresholds of tolerance or avoidance of habitat types. Previous research of coastal wolf habitat selection has focused primarily on den sites (Person and Russell, 2009) and the pup rearing period (Person, 2001). Wolves did not demonstrate distinct patterns of habitat selection outside of the denning season (Person, 2001); however, this research relied on VHF radio collar locations at course time intervals. Furthermore, as most attention has been paid to wolves' use of deer habitat, little is known about seasonal changes in wolf habitat selection reflecting use of other prey in temperate rainforests.

Wolves are expected to display preferences for different habitat types among seasons because of variation in behavior throughout the year. For example, during denning season, wolf activity is focused around the den site (Ruprecht et al., 2012) generally located in protected areas because of pup vulnerability (Mech and Boitani, 2003; Sazatornil et al., 2016), whereas territorial behavior increases during winter requiring more movement (Jędrzejewski et al., 2001; Smith et al., 2015) and potentially different habitat selection patterns (Ehlers et al., 2014). Foraging behavior may change throughout the year as wolves have been demonstrated to shift habitat selection seasonally, reflecting variability in prey availability or vulnerability (Peterson et al., 1984; Metz, 2012; Latham et al., 2013). Investigations of variation in seasonal foraging patterns have proved important for understanding predator-prey dynamics (Sand et al., 2008; Knopff et al., 2010; Metz et al., 2012) including apparent competition (Latham et al., 2011) and prey-switching behavior (Latham et al., 2013). Indeed, research using stable isotope ratios suggests coastal wolves switched dietary preference to salmon, a seasonally available resource, when deer became less abundant (Szepanski et al., 1999), or during periods of availability (during late summer and fall), regardless of ungulate abundance (Darimont et al., 2008).

Considering the concerns for coastal wolf viability, determining how wolves select specific forest successional stages is necessary to understand the effects of logging practices, and can inform evaluation of measures taken to mitigate negative consequences of timber harvest and enhance wolf habitat. Moreover, identifying differences in use of primary and alternate prey habitat throughout the year can reveal seasonal targeting of prey species. To address these issues, we investigated seasonal habitat selection of wolves on Prince of Wales Island, Alaska. To understand shifts in patterns of landscape preference throughout the year, we modeled the relative probability that certain resources were selected in relation to the distribution of forest type, land cover classes, topographical variables, road density, and availability of primary and alternate prey. We specifically tested for preferences in selection of productive old-growth forest classes, age of successional forest, and forests that had been treated to enhance deer habitat. We hypothesized that wolves would select habitats that best support deer, including old-growth forests and young successional clearcuts, and would avoid habitats that are unproductive for deer including clearcuts > 30 years old, particularly during winter. Second, we predicted that use of areas near salmon streams would increase with seasonal (late summer) availability of this alternative prey resource. Finally, we predicted that wolves would avoid areas of high road densities during the denning season because pups are vulnerable and less mobile at that time (Person and Russell, 2009; Benson et al., 2015). Conversely, we predicted that wolves would select high-density roaded areas during winter because of increased movement during this period, as roads have been demonstrated to facilitate movement and prey acquisition by wolves (Whittington et al., 2011; Dickie et al., 2016). Greater knowledge of variation in seasonal resource selection is important for understanding coastal wolf ecology and will help evaluate their potential to adjust to altered landscapes.

2. Materials and methods

2.1. Study area

The study area covered 3570 km^2 of temperate rainforest on POW, the largest island (6670 km^2) in the Southeast Alaska Archipelago (Fig. 1). The POW Island complex (9025 km^2) is characterized by an extensive coastline with long fjords, rugged mountains ≤ 1160 m, and multiple watersheds. A variety of habitat types are represented in this

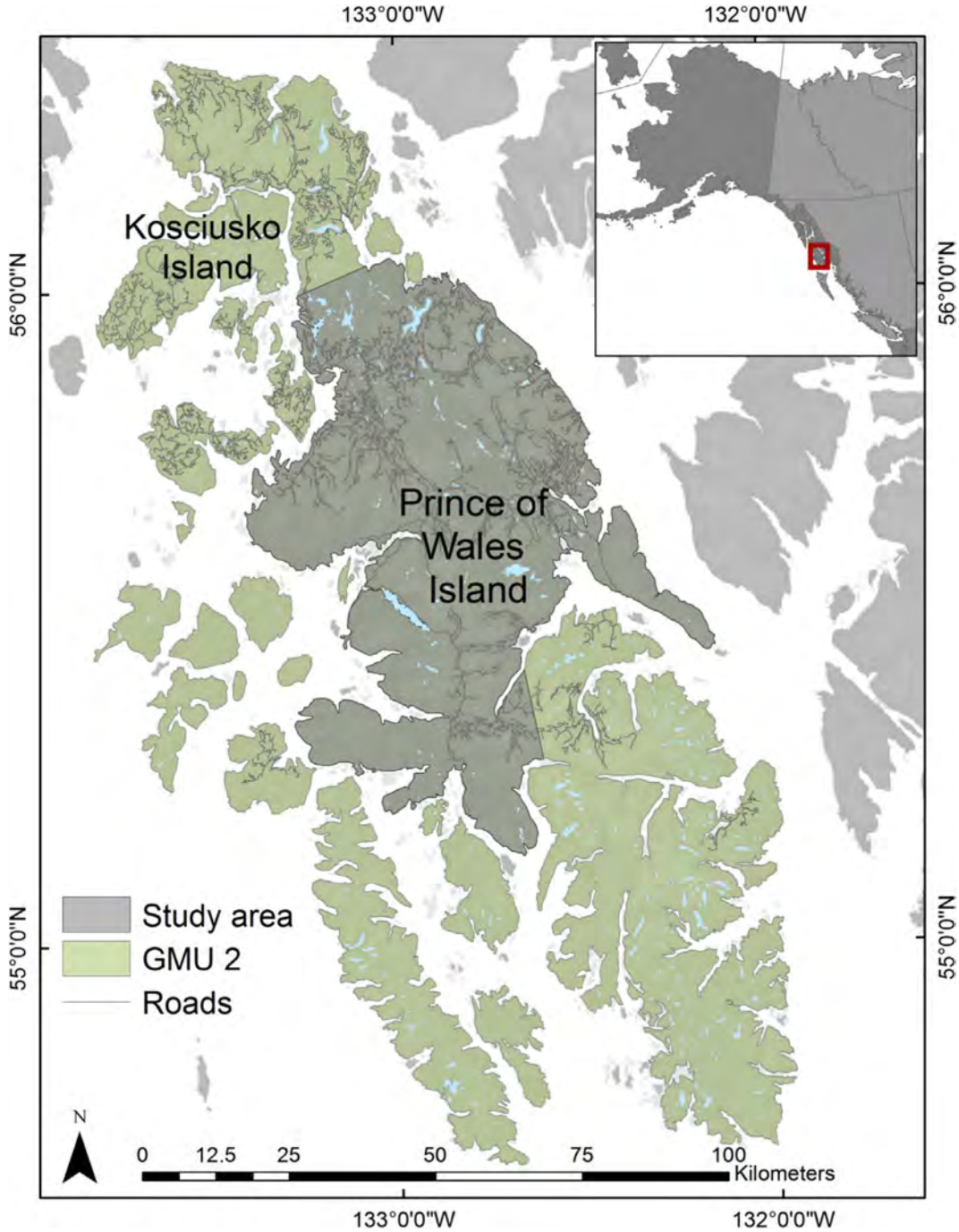

Fig. 1. Wolf seasonal resource selection study area (2012–2016) on Prince of Wales Island, Alaska, and the boundaries of Game Management Unit 2 (GMU 2).

area (Table 1). Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) are the dominant tree species with large forested areas common at lower elevations (< 600 m; Alaback, 1982). Old-growth (> 300 years) forest patches are structurally complex and diverse in understory species. On POW, old-growth forests are intermixed with blocks of even-aged forest stands at varying successional stages resulting from clearcut logging. Clearcuts ≤ 30 years after logging are brushy with young conifers and shrubs, and clearcuts > 30 years old have a homogenous structure with sparse understory and low species diversity (Wallmo and Schoen, 1980; Albert and Schoen, 2013). Other habitats include muskegs, marine estuaries, riparian and alpine zones. Annual precipitation ranges between 130 and 400 cm mostly in the form of rain, with intermittent snow during the winter months. Prince of Wales Island has had the highest rates of logging in Southeast Alaska, where contiguous high-volume forests have been reduced by 93.8% between 1954 and 2004 (Albert and Shoen, 2013). Approximately 4800 km of roads, the majority of which are graveled, secondary roads, have been built throughout POW to facilitate logging, with the highest road densities in northern POW (0.49–1.04 km/km^2; Person and Russell, 2008).

Wolves have been studied intensively on POW during 1993–1995 and 1999–2004 (Person, 2001; Person and Russell, 2008), and 2012 to the present. Wolf density on POW and the surrounding islands during these periods ranged from 39.5 wolves/1000 km^2 in 1994 on POW and Kosciusko Islands (6808 km^2; Person et al., 1996), to 9.9–24.5 wolves/1000 km^2 during 2013–2015 in Game Management Unit 2 (GMU 2), which includes POW and the surrounding complex of islands (9025 km^2; Roffler et al., 2016). Sitka black-tailed deer are the primary

Table 1
Habitat covariates used in wolf seasonal resource selection function models, % availability (for categorical covariates), and range and mean of values (for continuous covariates) within wolf pack home ranges on Prince of Wales Island, Alaska, USA, 2012–2016.

Abbreviation	Variable	Description	%, Range, Mean
Land cover			
ALP	Alpine	High elevation vegetation including sparse tree cover, herbs, shrubs, and lichens, also rock and snow	1%
LVPOG	Low-volume productive old-growth forest	Forest older than 150 years, trees ≥ 9″ dbh[a], 8–20 MBF[b]/acre on hydric soils, (also young growth from natural disturbance, and unproductive for timber harvest)	38%
MVPOG	Medium-volume productive old-growth forest	Forest older than 150 years, trees ≥ 9″ dbh, 8–20 MBF/acre on non-hydric soils, 20–30 MBF/acre on hydric soils	12%
HVPOG	High-volume productive old-growth forest	Forest older than 150 years, trees ≥ 9″ dbh, 20–30 MBF/acre on non-hydric (north aspect or flat) or hydric soils, 30 to ≥50 MBF/acre	17%
CC ≤ 30	Young clearcut forest ≤ 30 years	Young clearcut forest, 0–30 years after harvest	6%
CC > 30	Old clearcut forest > 30 years	Old clearcut forest, > 30 years after harvest	4%
OPEN	Open vegetated	Meadows, grasslands, and muskegs	3%
OTHER	Other non-forest	Freshwater lakes and wetlands, brush, urban areas	13%
THIN	Thinned forest	Precommercially thinned stands with at least 50% of total area thinned	6%
Topographic			
ELV	Elevation	Meters above sea level	0–1168, 239
SLP	Slope	Degrees	0–63, 14
ASP	Aspect	Four cardinal directions and flat	North = 23% East = 25% West = 27% South = 24% Flat = 1%
Landscape			
RDENS	Road density	Kernel density estimate of all road types at 100-m and 1000-m scales (km road/km^2)	0–4.439, 0.647
EDENS	Edge density	Kernel density estimate of edges at 100-m and 1000-m scales	0–10.02, 3.19
DISTFRESH	Distance to freshwater	Distance in meters to freshwater lakes and wetlands	0–8570, 1870
Prey			
DEER	Deer HSI	Habitat suitability index of deer carrying capacity	1–252, 123
DISTSS	Distance to salmon stream	Distance in meters to anadromous streams with documented salmon runs	0–5006, 1047

[a] Diameter at breast height.
[b] Thousand board-feet.

prey species of POW wolves, and beaver (*Castor canadensis*) and seasonally-available salmon are important secondary prey species (Kohira and Rexstad, 1997; Szepanski et al., 1999). Other mammals that are present and constitute a lesser portion of the diet include river otters (*Lontra canadensis*), black bears (*Ursus americanus*), other mustelids, marine mammals, and small rodents (Kohira and Rexstad, 1997; MacDonald and Cook, 2007).

2.2. Wolf location data

We modelled habitat selection within seasonal home ranges for 13 radiocollared wolves (8 females and 5 males) in 7 packs with 1–5 wolves radiocollared in each pack home range. We captured and radiocollared wolves during 2012–2016 using modified padded long spring (Easy-Grip® #7, Livestock Protection Company, Alpine, TX) and unpadded coil spring foothold traps (MB750, Minnesota Brand Inc.) set along the road system with commercially-produced lures and canid urine used as attractants. We immobilized restrained wolves using either tiletamine HCl and zolazepam HCl, or a combination of ketamine and medetomidine. We recorded sex, morphological data, and age category for each wolf. We ensured that capture and handling procedures conformed to guidelines established by the ADF&G Animal Care and Use Committee (ACUC #2012–028 and #2014–15) and the American Society of Mammalogists (Sikes and Gannon, 2011). We fit each captured wolf with a spread-spectrum, Global Positioning System (GPS) radio collar (Mod 4500, Telonics, Inc.) programmed to obtain a location every 6 h during 1 January–31 August, and every 2 h 1 September–31 December to coincide with the period of population estimation. We thinned wolf relocations during September–December to every 6 h to be consistent with the rest of the year. Collars were programmed to automatically release after 24 months, and had a VHF component for radiotelemetry and collar recovery after release.

We defined 4 seasons based on the life history of wolves in our study area: denning season (15 April–31 July), late summer (1 August–14 October), fall (15 October–31 December), and late winter (1 January–14 April). During the denning season wolf activity is focused around den sites until early to mid-July when wolf movements shift to rendezvous sites (Mech and Boitani, 2003; Person and Russell, 2009). Late summer encompasses the period when activity centers shift from dens to rendezvous sites from which wolves make forays within their home range. Pups become more mobile during this time and have changing nutritional requirements, therefore wolf resource selection may be substantially different than during the denning season (Benson et al., 2015). Previous investigations of radiocollared wolves on POW demonstrated that rendezvous sites are generally < 1 km from the den, and the wolves used the rendezvous sites as late as October (Person and Russell, 2009). Late summer is also the period when spawning salmon become available in streams on POW (Campell et al., 2012). Salmon are a seasonally-important part of the diet of coastal wolves (Kohira and Rexstad, 1997; Szepanski et al., 1999; Darimont et al., 2008), thus wolves may localize on anadromous streams during salmon spawning from late summer through October (Person, 2001; Person and Russell, 2009). Wolves become more mobile during the fall period and have larger home ranges (Person, 2001). During late winter wolves are nomadic, and breeding also occurs during this season (Mech and Boitani, 2003).

2.3. Habitat covariates

Our habitat selection models included covariates based on previous wolf habitat selection studies on POW (Person and Russell, 2009). We considered terrestrial habitat features representing variation in land cover, topographic features, and the landscape (Table 1). Land cover classifications were included as categorical covariates and were derived from the 'Size Density' (Caouette and DeGayner, 2005), 'Cover Type', and 'Activity' (i.e., thinning data), GIS layers from the USFS Tongass

(Southeast Alaska GIS Library; http://seakgis.alaska.edu/index.html). In these classifications we differentiated between young clearcuts (≤30 years since cut) and old clearcuts (> 30 years) because these successional stages are structurally distinct (Wallmo and Schoen, 1980; Albert and Schoen, 2013). We also classified forests that contained at least 50% precommercially thinned forest stands. The mean age of the forest stands at the time of treatment was 24 years (range 6–52 years). Vegetation classifications included low-, medium-, and high-volume old-growth forests, open vegetation (meadows, grasslands, and muskegs), other non-forest (freshwater, brush, urban areas), and alpine. We used medium-volume old-growth forest as the reference category.

We derived the topographic covariates slope, elevation (continuous covariates), and aspect (categorical covariate, with north and flat terrain as the reference category) across the study area using the Shuttle Radar Topography Mission (SRTM) digital elevation model (Farr et al., 2007). We included road and edge density (calculated using a kernel density estimate at 100-m and 1000-m scales) as continuous covariates. Edges were defined as the boundary between land cover classifications categorized as open (e.g. alpine, meadows, young clearcuts), and closed (e.g., old-growth forests, old clearcuts), and density was calculated with ArcGIS Spatial Analyst 'Line Density' function. We also included distance to freshwater lakes and wetlands as continuous landscape covariates.

We also included covariates related to habitat suitable to wolf prey species because landscape-level abundance estimates of deer and salmon are not available. A habitat suitability index (HSI) for deer (Suring et al., 1993) was based on a spatial model to estimate habitat capability of Sitka black-tailed deer during winter and served to provide an index of deer carrying capacity with the highest scores attributed to southern aspects, lower elevations, low snow level, and old growth stands (high-volume forests received the highest scores, whereas medium-, and low-volume forests ranked lower, but still substantially higher than other forest categories). Winter is considered to be the most restrictive time of the year for deer physically (Parker et al., 1996, Parker et al., 1999), and thus conserving high quality winter habitat would help sustain deer populations (Suring et al., 1993). Critical winter deer habitat is also considered to be a good measure of wolf habitat quality for wolves in Southeast Alaska (Person, 2001) where both species occur, and deer habitat capability is directly tied to models for wolf habitat capability (Suring et al., 1993). The deer HSI estimates habitat quality and is not intended to predict absolute deer numbers; instead, the HSI provides a relative index of carrying capacity. Given the assumptions that the HSI model indicates the relative ability of habitat to support deer, and that habitat suitability is correlated with abundance over the long-term, and that deer constitute the primary prey of wolves in this region, the HSI model has been used to estimate wolf population abundance across Southeast Alaska (Person et al., 1996, USFWS, 2015) and in population viability analyses related to management considerations such as the ESA (Gilbert et al., 2015, USFWS, 2015). Considering the ongoing application of this model to management, we wanted to explicitly investigate the relationship of seasonal wolf habitat selection to the deer HSI model. We expected HSI would indicate relative abundance of deer during winter and fall, as old growth forests, low elevations, and southern aspects are important to deer during these seasons, but that HSI would be less predictive of deer habitat during late spring and summer, when deer use higher elevations and young clearcuts in addition to old growth forests (Schoen and Kirchhoff, 1990; Person, 2009; Gilbert, 2015). We included deer HSI as a continuous covariate in models along with its components, as we wanted to investigate wolf response to the individual factors as well as the deer HSI, which was viewed as a more integrated perspective of wolf response to deer. Tests for multi-collinearity between HSI and its component factors did not reveal any significant correlations. We also included distance to anadromous streams as a continuous prey habitat covariate. We resampled all GIS data to a 30 m^2 cell resolution for spatial analysis. We used the R statistical environment and ArcMap 10.2.1 (ESRI 2013) to conduct all spatial and statistical analyses.

2.4. Habitat selection modelling

We evaluated wolf habitat selection at the third order (within the home range), following Johnson's (1980) hierarchy of scales of selection to compare locations used by wolves to those available within their seasonal home ranges. We estimated wolf habitat selection for each of the 4 seasons with resource selection functions (RSFs; Boyce and McDonald, 1999; Boyce et al., 2002; Manly et al., 2002) using generalized linear mixed models (Bolker et al., 2009) with the logit link. We evaluated models that included a random intercept for individual wolves nested within each pack. These random effects were included to accommodate the hierarchical structure of wolves (Hebblewhite and Merrill, 2008) and to mitigate effects of uneven sample sizes of pack home range locations and possible autocorrelation of used locations within packs (Pinheiro and Bates, 2000; Gillies et al., 2006).

We calculated seasonal home ranges to estimate habitat availability for each wolf pack using 95% minimum convex polygons (MCP; Mohr and Stumpf, 1966). Although MCPs do not provide information regarding variance of use of space within the polygon border, they are suitable for defining the extent of area used, and thus an appropriate method for characterizing available habitat within the home range. We used the rhr package (Signer and Balkenhol, 2015) in R 3.3.2 (R Core Team, 2016) to estimate 95% MCP seasonal home ranges for each wolf pack, and to calculate the minimum number of relocations necessary for home range areas to reach an asymptote. Following Laver and Kelly (2008) the asymptote was reached if the 95% confidence interval of bootstrapped home-range sizes fell within 5% of the total home range area (using all relocations) for at least 5 estimates. We clipped all MCP seasonal home ranges to the shoreline of POW, thus home range and habitat selection in this study are specific to terrestrial resources. We excluded wolf GPS relocations outside of 95% MCP home ranges calculated from locations of all collared pack members from analysis, including extraterritorial forays (temporary movements outside of home range that are markedly separate from their previous locations; Ballard, 1997; Burch et al., 2005), or dispersal events (permanent movement away from natal pack home range, not remaining in one place for > 14 days; Person and Russell, 2008). We also excluded wolves that did not exhibit fidelity to a home range (dispersers) as indicated by lack of a well-defined core area (Appollonio et al., 2004), as home-range estimation is not appropriate for such individuals. We randomly drew available habitat for each individual wolf within their respective 95% MCP at a ratio of 20 locations for every used location to ensure accurate habitat representation and reliable coefficient estimation, as recommended by Northrup et al. (2013). In addition to excluding locations of wolves outside of the seasonal 95% MCPs, we included used locations for only adult or yearling resident wolves within a given season. Resident wolves had well-defined home ranges that did not overlap those of neighboring packs and associated with other wolves in their pack.

We first screened individual habitat covariates for collinearity using a threshold cut-off of $r = 0.6$ (Hosmer and Lemeshow, 2000) or with variance inflation factors (VIF) > 10 (McCullagh and Nedler, 1989) to exclude collinear habitat covariates. We further assessed VIF for the global model (all covariates included) and combinations of potentially collinear covariates (McCullagh and Nedler, 1989). We standardized continuous covariates to enable comparison of their relative effect on wolf seasonal habitat selection. We determined the most predictive scale for road and edge density by conducting univariate analyses and selecting the scale with the lowest Akaike's Information Criterion, corrected for sample sizes (AIC_c) score. We examined potential quadratic linear distributions for nonlinear continuous covariates.

We then conducted model selection using AIC_c (Burnham and Anderson, 2002). We first developed a global model and evaluated biologically plausible candidate models that included subsets of the

Table 2
Number of radiocollared wolves, monitoring period, number of GPS collar locations by pack and season (denning season [15 April–31 July], late summer [1 August–14 October], fall [15 October–31 December], and late winter [1 January–14 April]), Prince of Wales Island, Alaska, USA, 2012–2016.

	Pack	Number radiocollared wolves	Monitoring period	Number locations
Denning	Honker	5	2012–2014	1007
	Hydaburg	1	2013	196
	Nossuk	1	2013	186
	Ratz	1	2012	179
	Sandy Beach	2	2015–2016	594
	Staney	2	2012–2015	518
	Trocadero	1	2016	227
	Mean	1.9		415
Summer	Honker	4	2012–2014	119
	Hydaburg	1	2013	190
	Nossuk	1	2013	119
	Ratz	1	2012	217
	Sandy Beach	2	2015	386
	Staney	2	2013–2014	434
	Trocadero	–	–	–
	Mean	1.8		244
Fall	Honker	6	2012–2014	1129
	Hydaburg	1	2013	126
	Nossuk	1	2013	205
	Ratz	1	2012	346
	Sandy Beach	2	2015	563
	Staney	1	2012–2013	689
	Trocadero	–	–	–
	Mean	2		510
Winter	Honker	4	2012–2014	988
	Hydaburg	–	–	–
	Nossuk	1	2012	407
	Ratz	1	2012	337
	Sandy Beach	2	2014–2015	234
	Staney	1	2012–2014	369
	Trocadero	1	2016	317
	Mean	1.7		442

best-supported covariates and interactions. These same 24 candidate models were evaluated for each season. We examined interactions hypothesized to be biologically meaningful, including the interactions between preferred habitats and road density, edge density, and distance to anadromous salmon streams (which was included as second-order polynomial). To evaluate the fit of the seasonal RSF models we used k-fold cross validation and Spearman's rank correlation (r_S) across 10 subsamples (Boyce et al., 2002). Analyses were conducted using the lme4 package with R software.

3. Results

3.1. Wolf habitat selection

GPS collars recorded on average 809 locations (SD = 415) per wolf, over a time interval of 401 days/collar. The average number of relocations per wolf per season was 242 (SD = 59) for the pup-rearing season, 186 (SD = 57) for late summer, 265 (SD = 194) for fall, and 276 (SD = 129) for late winter (Table 2). All 95% MCP home range areas reached an asymptote within the number of relocations available for each pack, thus all were retained for defining available habitat in the resource selection function models.

Wolf resource selection was a function of topographic and land cover covariates, as wolves consistently selected low elevation (mean = 143 m, SD = 142 m), flat terrain with open vegetation or low-volume old-growth forests across seasons. Selection for low elevations was strongest during the denning season, and flat terrain was most important during late summer and fall, although both habitat covariates were highly significant in all top-ranked seasonal habitat selection models (Table 3). Open vegetation and low-volume old-growth forests were selected more than the other land cover covariates in relation to medium-volume old-growth forest (the reference category). The open vegetation class (including muskegs, meadows and grasslands) was one of the most important habitat covariates in all seasonal models, especially in late summer ($\beta = 0.796$, SE = 0.162, $P < .001$), fall ($\beta = 1.428$, SE = 0.072, $P < .001$) and winter ($\beta = 1.334$, SE = 0.097, $P < .001$), although still significant during the denning season ($\beta = 0.594$, SE = 0.104, $P < .001$). Low-volume old-growth forests

Table 3
Standardized selection coefficients (β), standard errors (SE), and significance level for seasonal resource selection functions for wolves on Prince of Wales Island, Alaska, USA, 2012–2016. Covariate values in bold are significant at α = 0.05. Elevation (ELV), slope (SLP), aspect (ASP), road density at the 1000-m scale (RDENS), edge density at the 1000-m scale (EDENS), distance to freshwater (DISTFRESH), deer habitat suitability index (DEER), distance to anadromous stream ($DISTSS^2$), low-volume productive old-growth forest (LVPOG), young clearcut forest ≤ 30 years (CC ≤ 30), old clearcut forest > 30 years (CC > 30), open vegetation (OPEN), other land classification (OTHER), thinned forest (THIN).

	Den			Late summer			Fall			Winter		
Covariate	β	SE	p	β	SE	p	β	SE	p	β	SE	p
ELV	**−0.787**	**0.036**	**< 0.001**	**−0.378**	**0.040**	**< 0.001**	**−0.400**	**0.028**	**< 0.001**	**−0.407**	**0.036**	**< 0.001**
SLP	**−0.423**	**0.035**	**< 0.001**	**−1.025**	**0.049**	**< 0.001**	**−0.800**	**0.035**	**< 0.001**	**−0.441**	**0.039**	**< 0.001**
ASP − South							**0.146**	**0.042**	**< 0.001**	**5.254**	**0.150**	**< 0.001**
ASP − East										**−1.284**	**0.060**	**< 0.001**
ASP − West										**−0.902**	**0.059**	**< 0.001**
RDENS	**−0.269**	**0.025**	**< 0.001**	**−0.397**	**0.036**	**< 0.001**	**−0.055**	**0.022**	**0.014**	**0.197**	**0.030**	**< 0.001**
EDENS	**−0.060**	**0.025**	**0.007**	0.018	0.030	0.549	**−0.095**	**0.022**	**< 0.001**			
DISTFRESH										**0.201**	**0.026**	**< 0.001**
DEER				**0.189**	**0.033**	**< 0.001**	**0.111**	**0.023**	**< 0.001**			
$DISTSS^2$				**0.115**	**0.034**	**0.001**						
LVPOG	**0.411**	**0.047**	**< 0.001**	**0.692**	**0.064**	**< 0.001**	**0.490**	**0.047**	**< 0.001**	**0.470**	**0.066**	**< 0.001**
CC ≤ 30							**0.357**	**0.074**	**< 0.001**	**0.286**	**0.094**	**0.002**
CC > 30							−0.101	0.092	0.273	**−0.421**	**0.125**	**0.001**
OPEN	**0.594**	**0.104**	**< 0.001**	**0.796**	**0.132**	**< 0.001**	**1.428**	**0.072**	**< 0.001**	**1.334**	**0.097**	**< 0.001**
OTHER				**0.676**	**0.098**	**< 0.001**				**0.282**	**0.136**	**0.038**
THIN										**−0.489**	**0.113**	**< 0.001**
EDENS:OPEN				**0.230**	**0.078**	**< 0.001**						
RDENS:OPEN	**−0.284**	**0.120**	**0.018**	**−0.605**	**0.143**	**< 0.001**						
DISTSS:OPEN				**−0.579**	**0.139**	**< 0.001**						
RDENS:DEER							**−0.063**	**0.019**	**0.001**			
RDENS:OTHER										**−0.389**	**0.143**	**0.007**

were most strongly selected during fall and winter relative to medium-volume old-growth, and high-volume old-growth did not contribute to the top models for any season (Table 3).

During the denning season and late summer, wolf habitat selection was negatively correlated with high road density at the 1000-m scale (Table 3). In areas with high road densities wolves avoided open land cover during late summer even though this habitat type was one of the most important predictors of wolf habitat selection across all seasons. Wolves used areas with a mean road density of 0.772 km/km^2 during denning season, 0.686 km/km^2 during late summer, and 0.406 km/km^2 in open habitats during late summer (road density in the study area ranged from 0 to 4.439 km/km^2 at the 1000-m scale). Wolves weakly avoided areas of high road densities during fall ($\beta = -0.055$, SE = 0.022, $P = .014$), but this relationship switched during winter when wolves strongly selected highly roaded areas (Table 3). Areas of high edge densities at the 1000-m scale were also avoided by wolves during the denning season and fall, but selected during late summer in areas where they coincided with open vegetation classes (Table 3). Road density and edge density at the 100-m scales were not significant in the top-ranking seasonal habitat selection models (Table S1, Supplementary materials).

During fall and winter wolves selected clearcuts ≤30 years old, and strongly avoided clearcuts > 30 years old more than medium-volume old-growth forest, particularly during winter ($\beta = -0.421$, SE = 0.125, $P < .001$). Wolves also strongly avoided forest stands during winter that had received thinning treatments. This forest management category was not a significant habitat covariate in any of the other seasonal RSF models. Wolves selected areas of predicted high deer carrying capacity (high HSI values in south-facing, low elevation, high-volume old growth forest) only during late summer and fall. In areas of high road densities during fall, the relationship reversed and wolves instead avoided high suitability deer habitat in these areas (Table 3). Distance to anadromous salmon streams entered only the late summer resource selection function models. Wolves used areas at a mean distance of 917 m to anadromous streams during late summer, and selection of areas close to streams increased in areas of open vegetation classes ($\beta = -0.579$, SE = 0.139, $P < .001$). The other non-forest land cover category (including freshwater lakes, wetlands, brush, and urban areas; Table 1) was selected by wolves during late summer ($\beta = 0.676$, SE = 0.098, $P < .001$) and winter ($\beta = 0.282$, SE = 0.136, $P = .038$). Examination of used locations in this category revealed that during late summer, wolves selected areas adjacent to lakes and anadromous streams. During winter, the majority of used locations in this land cover category were in close proximity to the shore line (< 1.5 km), or on the edges of freshwater lakes.

Aspect was a significant habitat covariate only for the fall and winter resource selection functions, when wolves selected south facing terrain (in relation to north aspects and flat terrain, the reference category). Indeed, southern topography during winter was the most strongly selected covariate based on standardized coefficients of any habitat type for any season (Table 3). Wolves avoided eastern and western aspects during winter. The top models for each season performed well in the Spearman rank correlation from the k-fold cross-validation ($r_S = 0.951$–0.966).

4. Discussion

Within their seasonal home ranges, wolf habitat was defined by topography (low elevation, flat terrain) and mostly unmodified land cover (open vegetation and low-volume old-growth forests) across all seasons. Our results supported the hypothesis that wolves select forest categories indicative of high quality deer habitat (low-volume old-growth forests and young successional clearcuts) in relation to the reference category, but not those presumed to be the highest quality deer habitats (high-volume old-growth). Wolves avoided low-quality deer habitat (old clearcuts) especially during winter. Wolf selection of areas near salmon streams was significant only during late summer, providing evidence supporting our second hypothesis. Finally, our results confirm that wolves avoided areas of high road densities during the denning season but selected high-density roaded areas during winter.

Seasonal resource selection by wolves indicated a strong preference for certain high-quality deer habitat and demonstrated that wolves shift habitat use seasonally especially with regard to road density. We found the strength of selection by wolves increased with suitability of deer habitat within their late summer and fall home ranges (Table 3). During the denning season, despite an affinity for low-volume old-growth forest and low elevations, selection for high quality deer habitat (measured by the deer HSI, Suring et al., 1993) was less apparent than for other seasons. There are two non-mutually exclusive potential explanations for this pattern. First, as the deer HSI was intended to predict carrying capacity of deer considering physiological limitations imposed during winter, results could indicate this index is a poor predictor of seasonal deer habitat use during early summer. While deer select old growth forests, low elevations, and southern aspects year-round, during late spring and summer deer also make use of higher elevations and young clearcuts (Schoen and Kirchhoff, 1990; Person, 2009; Gilbert, 2015). Deer movements are relatively less restricted during this time than other seasons, and use of higher elevations by some deer begins as early as May (Schoen and Kirchhoff, 1985), a strategy with demonstrated fitness advantages including larger body size and higher reproductive rates (Klein, 1965). Another fitness-conferring strategy for deer is to use young clearcuts to maximize forage intake during summer, which enables energetically demanding lactation (Parker et al., 2009), and ability to increase body reserves as a buffer against nutritional stress experienced during winter (Parker et al., 1999). Deer on POW favor clearcuts 10–25 years old (Yeo and Peek, 1992; Person et al., 2009; Gilbert, 2015) during summer, as this age class of clearcut provides the highest abundance of summer forage, relative to other habitats (Alaback, 1982; Farmer et al., 2006). Wolves did not select young clearcuts during the denning period, indicating little overlap with preferred deer habitat during this season.

Second, patterns of wolf habitat selection during the denning season could indicate that reproductive activities (i.e., den site selection, pup rearing) took precedent over deer hunting. Wolves have restricted movements and foraging patterns during the denning season (Mech and Boitani, 2003). Earlier studies (Person, 2001) provide evidence that wolf home ranges in this area are significantly constrained during the denning season compared to fall (mean MCP pup-rearing [15 April–15 August] = 104.7 km^2; mean annual MCP = 259.7 km^2), and results from the current study also indicate smaller home ranges during denning season than fall and winter. While the highly synchronized birthing period of deer occurs the third week of May (Gilbert, 2015), providing an influx of vulnerable prey, the majority of neonate fawn mortality on POW was from black bear predation, not wolves (Gilbert, 2015). In order to remain in close proximity to their den sites, wolves may be targeting alternative prey that are more accessible, including beaver (Person and Russell, 2009). Indeed, most den sites were adjacent to freshwater and had evidence of recent beaver activity nearby (Person and Russell, 2009; ADF&G, unpublished data). By mid-July, wolves move to rendezvous sites (Person and Russell, 2009), and as pups become more mobile and require less attendance, wolves may increase hunting activities of deer, reflected in wolf selection of high suitability deer habitats during summer and fall.

Wolf predation is the primary cause of deer mortality during winter aside from malnutrition and human harvest (Farmer et al., 2006; Person, 2009), indicating wolves may select habitats during this season to increase their encounters with deer. Our results demonstrated strong preference by wolves for the components of certain critical winter deer habitat (southern aspects, low elevation, old-growth forest), which were better predictors of wolf habitat selection than the integrated deer HSI. In Southeast Alaska, critical winter deer habitat is composed of old-growth forest on southern aspects below 250 m (Wallmo and

Schoen, 1980; Kirchhoff and Schoen, 1987; Suring et al., 1993), and the deer HSI model incorporates these attributes with variation in snowfall to predict the deer carrying capacity (Suring et al., 1993). Because deer habitat selection is modified by deep snow, the HSI become less predictive during severe winters. High-volume old-growth forests with snow-intercepting canopies are more important for deer in areas of higher snowfall (Schoen and Kirchoff, 1985), or during severe winters (Doerr et al., 2005; Gilbert et al., 2017), compared to areas with milder winter climates (Yeo and Peek, 1992). Conversely, deer make greater use of young clearcuts during winters with less snow fall (Yeo and Peek, 1992; Gilbert, 2017), although this strategy comes with consequences for survival as selection of young clearcuts during low-snow periods by deer was positively associated with risk of death by wolf predation (Farmer et al., 2006).

During our study, Prince of Wales Island experienced relatively mild winters with little snowfall (NOAA online weather data), and wolves selected young clearcuts during fall and winter (although less than for low-volume old-growth). Previous wolf research demonstrated variation in selection for closed-canopy (snow-intercepting) old-growth during winter, and attributed spatial patterns of selection by different wolf packs to variation in snow accumulation across POW (Person, 2001). During his study, wolves in the northcentral regions of POW (overlapping the contemporary home ranges of the Honker and Ratz packs; Fig. 2) experienced deep snow during the winters of 1993–1995 (> 60 cm) and selected closed-canopy old growth forest relative to its availability (Person, 2001). In comparison, Koskiusko Island and the west side of POW received less snow (< 20 cm), and the resident wolf packs either weakly selected open-canopy old-growth (abundant understory vegetation but poor snow-interception qualities), or had no distinct patterns of selection (Person, 2001). Wolf packs avoided (n = 3) clearcuts and seral forest or demonstrated no pattern of selection (n = 4) for these habitats. In comparison, our results reveal strong selection for clearcuts and low-volume old-growth during winter (Table 3).

The most parsimonious wolf winter model was largely driven by strong selection for southern aspects (relative to northern aspects and flat terrain), which had the highest standardized coefficient of selection for any covariate in any seasonal model (Table 3). These results suggest wolves shift selection seasonally to target the most important deer habitat. Previous research showed southern aspects near shore line were better predictors for deer habitat use than forest type due to increased exposure of warm southeast winter storms that reduce the snow pack (Doerr et al., 2005). Further, southern aspect is an important modifying factor determining selection of open-canopy forests by deer in winter (Person et al., 2009), illustrating interactions between variation in snow depth and forest stand age (i.e., old-growth, young clearcut, old clearcut).

The most wide-spread anthropogenic effect on northern temperate forest ecosystems is silviculture, resulting in habitat fragmentation and long-term modifications of forest structure. The ability of wolves to persist in altered ecosystems depends in part on their ability to adapt their behavior to accommodate potential changes in prey distribution. In this research, we found wolf habitat selection patterns favored natural forest and land cover, mixed use of roads, and limited use or avoidance of human-caused seral forests. In relation to the landcover reference category wolves consistently selected low-volume old-growth forest, the forest class containing the lowest density of large diameter trees of all classes, but the highest forage biomass (Alaback, 1982). Our work corroborates previous research indicating that wolves selected this forest type significantly more than expected based on its availability (Person and Ingle, 1995; Person et al., 2001). Although wolves selected young clearcuts during fall and winter, this young-growth forest category did not factor into the denning and summer RSF models, demonstrating limited seasonal use. More importantly, wolves avoided old clearcuts during fall and winter, indicating that young-growth forest has a limited time frame of potential use by wolves, similar and likely related to predictions for use by deer (≤ 30 years post clearcut). Young-growth treated with precommercial thinning is intended to enhance deer habitat by delaying stem exclusion and prolonging forage production (DellaSala et al., 1996; Hanley, 2005; Cole et al., 2010). However, wolves avoided thinned forest during winter, and did not display patterns of selection for thinned forest stands during other seasons (Table 3) confirming previously described patterns of avoidance of second growth in the stem exclusion phase, in particular precommercially thinned stands (Person, 2001). Thus far, the benefits of thinning treatments on maintaining understory vegetation have proven to be short-term (5–10 years), diminishing the potential for sustaining wildlife through the long-lasting stem exclusion phase (Hanley, 2005; Farmer et al., 2006; Cole, 2010). In this study we demonstrate that thinning treatments do not thus far appear to enhance habitat for wolves. Thinning treatments recommended by the interagency Wolf Technical Committee (2017) for Prince of Wales Island include thinning prior to 25 years post-harvest in medium to high productive stands, prioritizing landscapes with low proportions of high quality winter deer habitat, and conditions that would favor understory regeneration. These treatments warrant continued evaluation for the benefits provided to both deer and wolves. Approximately 1500 km^2 of forest (representing over one third of the old-growth available prior to industrial logging) is predicted to enter the stem exclusion phase over the next two decades on POW and the surrounding islands (Smith et al., 2016) raising concern for the long-term abundance of predator and prey populations in logged temperate forests.

Use of alternate prey may indicate wolves' ability to tolerate landscape-level changes such as succession debt that could diminish the abundance of their primary prey. Wolves in Southeast Alaska have access to spawning salmon during late summer through early autumn (Kohira and Rexstad, 1997; Szepanski et al., 1999; Person, 2001), providing a seasonal source of prey that is spatially and temporally predictable, and requires relatively little handling time (Willson and Halupka, 1995). Salmon are present in approximately 2000 streams throughout Southeast Alaska (Sugai and Burrell, 1984), and northern POW contains the highest quantity of anadromous freshwater habitat in this region (Schoen and Dovichin, 2007). The primary salmon runs on POW are pink (*O. gorbuscha*) and chum (*O. keta*), occurring in late summer. Other salmon species present are sockeye (*O. nerka*) and coho (*O. kisutch*), which are less abundant, but the fall coho run extends the period of availability. Our results indicated that wolves select areas near anadromous salmon streams only during late summer (August–mid-October), coinciding with the salmon spawning period. Previous research also demonstrated selection by wolves of habitats near the mouths of anadromous streams during August–September (Person, 2001). Selection of areas near salmon streams increased in open habitats, which in our study area included meadows and grasslands, common in estuarine areas. Changes in wolf habitat selection to access spawning salmon indicate seasonal prey switching, and corroborates previously identified shifts in the proportions of primary and alternate prey consumed during summer. Kohira and Rexstad (1997) determined fish were the second most important prey species after deer during September–November and occurred in 21% of POW wolf scats. However, fish were not found in scats during the remainder of the year, and thus annual occurrence of fish in wolf scats was 5%, in comparison to other alternate prey species such as beaver (31%), black bear (8%), river otter (8%), and small mustelids (9%) that were consumed throughout the year. Despite the relatively narrow window of availability, Szepanski et al. (1999) determined that salmon made up 19.1% of the lifetime diet of POW wolves. Thus, although the season is limited temporally, the dietary contribution of salmon is large. Our results suggest the ability of wolves to shift seasonal foraging patterns spatially, and prioritize selection of specific resources corresponding with periods of prey availability.

Flexibility by wolves in spatial responses to anthropogenic features was demonstrated by seasonal patterns of selection and avoidance of

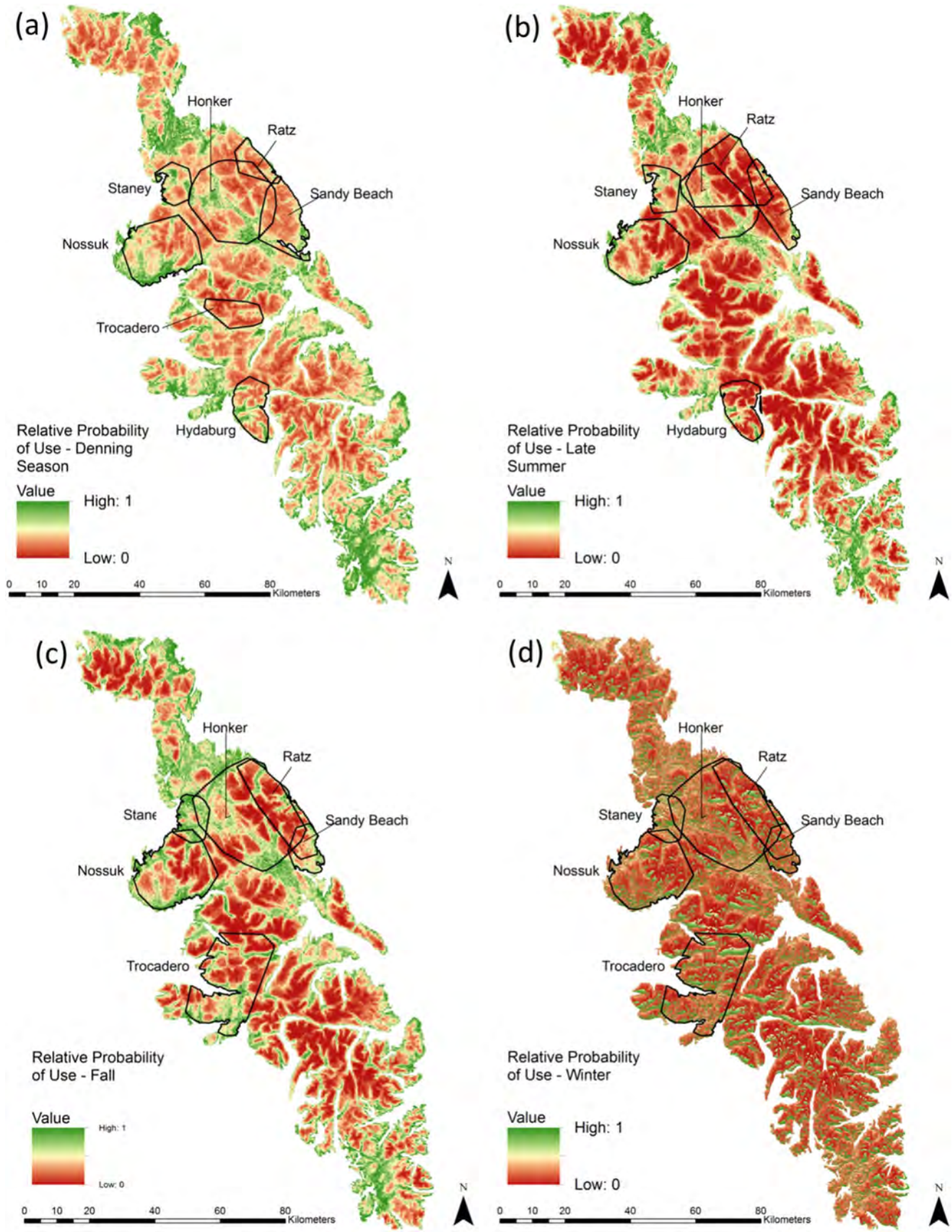

Fig. 2. Relative probability of use predicted by seasonal resource selection functions and wolf pack home ranges estimated using minimum convex polygons (MCPs) during (a) denning season, (b) late summer, (c) fall, and (d) winter on Prince of Wales Island, Alaska, USA, 2012–2016.

roads. Wolves have been shown to avoid roads when they coincide with areas of high human density (Dellinger et al., 2013), select roads to increase movement efficiency for territorial behavior and prey acquisition (Whittington et al., 2011; Zimmerman et al., 2014; Dickie et al., 2016), display flexibility in their responses to roads with higher use during night (Hebblewhite and Merrill, 2008; Zimmerman et al., 2014; Benson et al., 2015), or demonstrate differential responses to paved and unpaved roads (Ciucci et al., 2003). Seasonal differences in use of roads have also been documented with higher selection during fall and winter when wolves are nomadic (Houle et al., 2010; Lesmerises et al., 2013), and avoidance during the denning and rendezvous period (Person and Russell, 2009; Benson et al., 2015). Our results are similar to patterns detected in other areas of human disturbance as wolves on POW avoided areas of high road density during denning season and late summer but selection increased with increasing road density during winter. Wolves on POW have demonstrated aversion to human contact during denning season (Person and Russell, 2009) and responded to nearby disturbance from logging (low-level helicopter flights) by relocating a den site 0.36 km (G.H. Roffler, unpublished data). Active den sites on POW during 2012–2016 were on average 0.91 km from the nearest road (range = 0.17–3.83 km, SD = 1.07 km). In contrast, during the fall and winter, wolves were commonly documented on or near secondary roads with trail cameras and at hair snare stations established for estimating fall population densities with noninvasive capture-recapture methods (Roffler et al., 2016).

Road density was an important interaction term in seasonal habitat selection models. Whereas wolves selected habitats consistent with high-quality deer habitat during fall, and weakly selected areas of high road densities, when these two habitats coincided they were instead avoided (Table 3). A possible explanation for this modification of behavior is heavy deer hunter traffic on the POW road system during fall, with use peaking in late October but continuing through the end of December. During the 2012–2015 deer hunting seasons, an annual average of 1569 (SD = 8.22) hunters used road vehicles, off-road vehicles, or ATVs to travel along the road system (ADF&G, unpublished data). As hunters were likely also targeting high-quality deer habitat, wolves were possibly avoiding human contact at this time due to disturbance from noise, or avoiding risk of mortality by humans. Although wolf mortality from ground shooting (19.4% of wolves harvested during 2012–2015) on POW is less common than trapping or snaring, wolves may be shot opportunistically while hunters are targeting deer or other game species, as half the wolves shot during our study occurred during the deer hunting season. Road avoidance also increased during late summer in open vegetation habitats including muskegs and estuarine meadows which are used by POW wolves as rendezvous sites as late as October (Person and Russell, 2009). Selection of this habitat type was significant during the rendezvous period, as it provides important habitat for wolf pack interactions, and our results suggest wolves prefer these sites in areas of low road density.

5. Conclusion

Wolves appear to have the ability to use a variety of habitat types, although use of human-caused early succession forests had a short time frame, seral forests > 30 years were avoided, and forestry management to enhance habitat value in older seral forests did not extend the period of favorable conditions. Thus, the amount of habitat available to wolves could decline with an increasing proportion of the forest transitioning to the stem exclusion phase, with potential population-level consequences for wolves. Wolves displayed a variable response to road density confirming a high degree of adaptability to certain human-modified features. Wolves also shifted patterns of habitat selection towards alternate prey habitat (salmon) when seasonally available confirming flexibility in predation patterns (Peterson and Ciucci, 2003). However, to better forecast wolf resilience to the predicted decline of deer abundance resulting from succession debt, it is necessary to gain further knowledge about wolves' use of alternate prey such as beaver, mustelids, black bears, and marine mammals throughout the year. The results of this work provide insights for understanding the potential consequences of landscape-level management practices on coastal wolves.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.foreco.2017.11.025.

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Original Article

Estimating Abundance of a Cryptic Social Carnivore Using Spatially Explicit Capture–Recapture

GRETCHEN H. ROFFLER,[1] *Alaska Department of Fish and Game, Division of Wildlife Conservation, 802 3rd Street, Douglas, AK 99824, USA*

JASON N. WAITE, *Alaska Department of Fish and Game, Division of Wildlife Conservation, 802 3rd Street, Douglas, AK 99824, USA*

KRISTINE L. PILGRIM, *National Genomics Center for Wildlife and Fish Conservation, Rocky Mountain Research Station, U.S. Department of Agriculture Forest Service, 800 E Beckwith, Missoula, MT 59801, USA*

KATHERINE E. ZARN, *National Genomics Center for Wildlife and Fish Conservation, Rocky Mountain Research Station, U.S. Department of Agriculture Forest Service, 800 E Beckwith, Missoula, MT 59801, USA*

MICHAEL K. SCHWARTZ, *National Genomics Center for Wildlife and Fish Conservation, Rocky Mountain Research Station, U.S. Department of Agriculture Forest Service, 800 E Beckwith, Missoula, MT 59801, USA*

ABSTRACT Estimating population abundance of wolves (*Canis lupus*) in densely forested landscapes is challenging because reduced visibility lowers the success of methods such as aerial surveys and enumeration of group size using radiotelemetry. However, regular population estimates of wolves are necessary for population monitoring and sustainable management. We used noninvasive hair snaring and spatially explicit capture–recapture (SECR) to estimate wolf abundance on Prince of Wales Island (POW), Alaska, USA, during 2012–2015. We monitored 36–82 hair-snare stations weekly for 9–11 weeks during autumn. The noninvasive study area covered 1,683 km^2 during 2012–2013 and was expanded to 3,281 km^2 during 2014–2015. We identified 57 individual wolves during the study period using DNA from hair follicles genotyped at 10 microsatellite loci. We used population density estimates using SECR (2013: 24.5 wolves/1,000 km^2 [95% CI = 14.4–41.9 wolves/1,000 km^2], 2014: 9.9 wolves/1,000 km^2 [95% CI = 5.5–17.7/1,000 km^2], 2015: 11.9 wolves/1,000 km^2 [95% CI = 7.7–18.5 wolves/1,000 km^2]) to predict the autumn population for the POW management unit (2013: 221.1 wolves [95% CI = 130–378]; 2014: 89.1 wolves [95% CI = 49.8–159.4]; 2015: 107.5 wolves [95% CI = 69–167]). We detected and redetected more wolves and increased the precision of the density estimate after increasing the hair sampling intensity and sampling area in 2014–2015. Our results demonstrate that estimating wolf abundance using noninvasive sampling and SECR was feasible and reliably applied producing a statistically robust population estimate for monitoring wolf populations in densely forested areas. These methods have promise for application to widely ranging carnivores at population-level scales and may be especially useful when regular density estimates are necessary for management and conservation. © 2019 The Wildlife Society.

KEY WORDS *Canis lupus*, monitoring, noninvasive genetic sampling, population estimation, spatially explicit capture–recapture, wolf.

Estimating population abundance of carnivores in densely forested landscapes is challenging because of their cryptic nature, including nocturnal behavior, avoidance of humans, large home-range areas, and low densities. Wolves (*Canis lupus*) are renowned as one of the most difficult species to survey, particularly in areas with dense forest cover and lack of snow (Boitani 2003). One of the most common means to estimate wolf density is aerial telemetry of marked individuals, wherein wolves are radiocollared from every pack in the survey area, minimum counts of pack sizes are obtained visually through aerial observations, and the total number of wolves is divided by the sum of the pack territory areas (i.e., territory mapping; Peterson et al. 1984, Fuller 1989, Hayes 1995). The aerial radiotelemetry approach has been widely used since the 1970s and remains commonly applied in areas with open terrain (Ballard et al. 1997, Hayes et al. 2003, Adams et al. 2008, Lake et al. 2015, Boertje et al. 2017). This method is effective if a sufficient number of wolves are radiocollared and monitored in all adjacent packs in a region (Burch et al. 2005); yet, meeting these requirements is generally expensive, time-consuming, and difficult to apply over a large area (Boitani 2003, Schmidt et al. 2017). This method is also less successful in areas with

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[1]*E-mail: gretchen.roffler@alaska.gov*

thick forest canopies that hinder visibility, when wolf populations are large, or when pack turnover is high due to mortality. Aerial snow-tracking is another widely used method to survey wolves (Gasaway et al. 1983, 1992; Hayes et al. 2003; Gardner and Pamperin 2014; Kojola et al. 2014). Snow-tracking is most effective in open or semiforested terrain, although this method has been used in forested landscapes at high expense (Patterson et al. 2004). Snow-tracking also requires consistent snow cover during the survey period. In many regions occupied by wolves, snow cover is variable or absent, particularly in temperate areas (Blanco and Cortés 2012, Liberg et al. 2012). However, regular population estimates of wolves are necessary, even more so in areas where there is elevated concern for population management or conservation.

In southeastern Alaska, USA, wolves inhabit temperate rainforests distributed across the mainland coast and most large islands south of Frederick Sound (Fig. 1). Concerns about the conservation status of wolves in southeastern Alaska have intensified the relevance of obtaining current population estimates. Attention has largely focused on Prince of Wales Island (POW; Fig. 1), containing approximately one-third of the southeastern Alaskan wolf population (Person et al. 1996). The U.S. Fish and Wildlife Service (USFWS) conducted 12-month Endangered Species Act reviews of the Alexander Archipelago wolf (*C. l. ligoni*) on 3 occasions in the past 2 decades (USFWS 1995, 1997, 2016). Although listing was determined not warranted at the time of the decisions, these reviews raised questions about the long-term viability of POW wolves because of declining habitat quality and human harvest.

The U.S. Forest Service (USFS) manages the Tongass National Forest, which encompasses the majority of the land in southeastern Alaska. The wolf is a management indicator species in the Tongass National Forest Land and Resource Management Plan (USFS 1997, 2008). Recently, the USFS developed forest-management recommendations for maintenance of sustainable wolf populations (Wolf Technical Committee 2017). In 2014, the Alaska Department of Fish and Game (ADF&G) responded to concerns over the POW wolf population by reducing wolf harvest in Game Management Unit 2 (GMU 2; encompassing the POW Island complex; Fig. 1) to 20% of the autumn population estimate from the previous 30% limit.

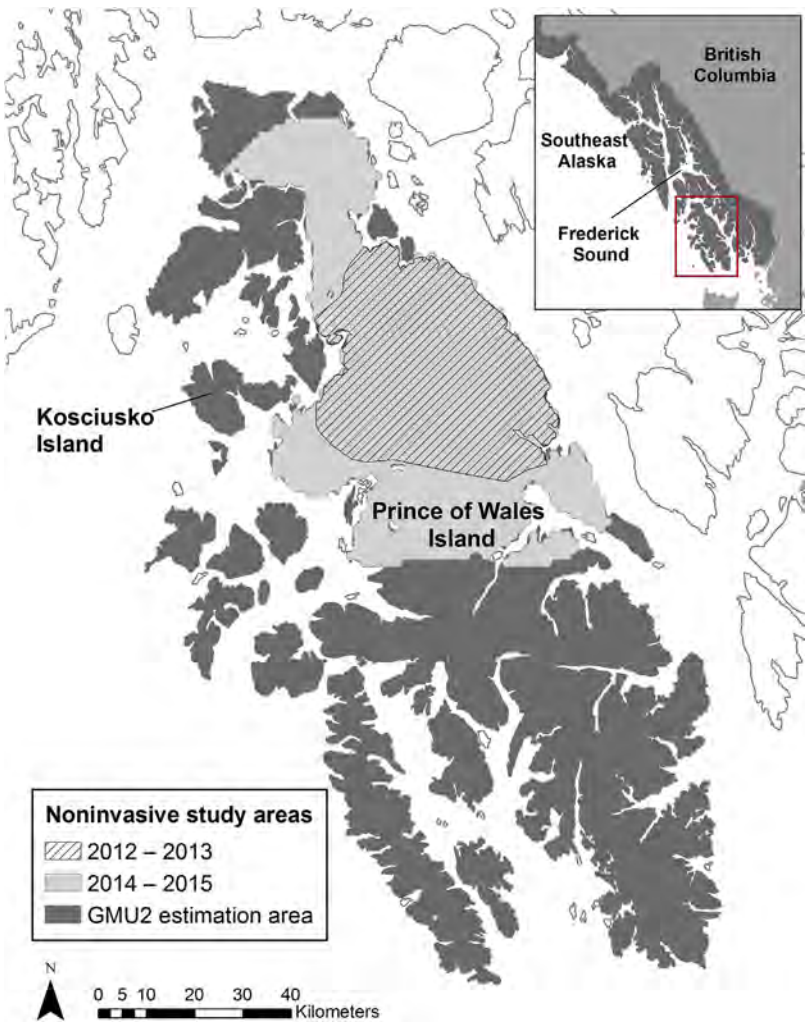

Figure 1. Study area for wolf population estimates using noninvasive hair snaring to collect DNA for spatially explicit capture–recapture, Prince of Wales Island, Alaska, USA, 2012–2015. GMU2 is Game Management Unit 2.

Until this study, the most recent autumn wolf-population estimate was $\widehat{N} = 269$ (SE = 80) for a portion of GMU 2 (POW and Kosciusko Islands = 6,808 km^2; Person et al. 1996). The estimate was produced using radiocollared wolves to locate packs and aerially count the pack members (Person et al. 1996). Population estimation was not repeated in following years because of the expense and high intensity of effort required to maintain and monitor a sample of radiocollared wolves on POW. However, regular population estimates at shorter intervals are desirable for monitoring populations and evaluating management strategies to ensure they are sustainable. To address this information gap, we sought to rigorously test an alternate population estimation technique that could be applied in this environment. Genetic capture–recapture using DNA from hair has been used to estimate population abundance of cryptic species living in dense forests (Kendall et al. 2008, Russell et al. 2012, Morton et al. 2016), including wolves (Stenglein et al. 2010; Ausband et al. 2011, 2014; Stansbury et al. 2014). The development of spatially explicit capture–recapture techniques (SECR; Efford 2004) has provided a means to estimate animal density by incorporating spatial detection histories of individual animals from locations of animal captures and movements. The spatial detection histories are used to fit a spatial model representing the distribution of the animal home ranges (the state model), and a spatial model of the detection process (the observation model). The probability of detecting an animal is then related to the distance between its activity center and the detector. Successful application of SECR requires multiple recaptures of the same individuals in different locations; therefore, it was necessary to assess our ability to detect and redetect individual wolves from noninvasive samples. Wolves, like many large carnivores can exist at relatively low densities, and their cryptic nature can contribute to sparse data sets (Russell et al. 2012). For robust parameter estimation (resistant to violations of model assumptions) using spatial-capture–recapture a sample size of $\geq$20 recaptures is recommended (Efford 2004, Efford et al. 2009). Even at these low captures rates, estimates of the range parameter σ have negligible bias (0.75%), though precision is substantially greater as capture rate increases (Borchers and Efford 2008).

Wolves are social carnivores and their behavior patterns may contribute to several unique situations that are necessary to consider in a study design. Wolves function as a pack and share the same home range, so their individual movements may not be independent. The SECR method assumes that the distributions of animal activity centers and animal movement are independent; therefore, social carnivore behavior such as group aggregation and territoriality violate this assumption. Although mean parameter estimates are not likely to be affected, violating this assumption results in overdispersion; thus, variance estimates would be biased low with 95% confidence intervals that are narrower than they would be otherwise (Efford 2004). Scenarios of nonindependence and spatial aggregation of individual wolves were assessed in simulation analyses by López-Bao et al. (2018) and results indicated only a slight underestimation in population abundance of spatially aggregated individuals in comparison to independently distributed individuals. Therefore, aggregation of social carnivores in packs and movement patterns centered on pack territories should have only a minor effect on density estimates. However, further research on this topic would be beneficial for informing approaches to estimating density of group-living animals. Beginning in 2012, we initiated a project to address the need for timely and accurate wolf population information. We also conducted an evaluation of the extent of sampling area, sampling frequency, and density of sampling stations required to obtain robust population estimates along with the corresponding effort. We used DNA samples collected from hair to estimate autumn density using a SECR approach (Efford 2004, Borchers and Efford 2008, Kery et al. 2011, Royle et al. 2011). Additionally, we explored effects of increasing the extent and intensity of sampling on density estimates.

STUDY AREA

Prince of Wales was the largest island (6,670 km^2) in the southern portion of the southeastern Alaska Archipelago (Fig. 1). This land mass contained rugged mountains $\leq$1,160 m, multiple watersheds, and large tracts of temperate rain forests dominated by Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) at elevations below 600 m (Alaback 1982). Old-growth forest was distributed in a matrix interspersed with even-aged forest stands at different successional stages resulting from clearcut logging. Annual precipitation, mostly as rain, ranged from 130 to 400 cm, with intermittent snow during the winter months. Northern POW has the greatest rates of logging in southeastern Alaska (Albert and Schoen 2013). Approximately 4,800 km of roads were built throughout POW to facilitate logging, with the greatest road densities in northern POW (0.49–1.04 km/km^2; Person and Russell 2008, Person and Logan 2012). Prior to this study, high levels of wolf harvest (1.7–14.3 wolves/1,000 km^2, 2000–2009; Person and Logan 2012) occurred on northern POW. During 2012–2013, the wolf-capture and hair-collection study area covered 1,683 km^2 in the north-central portion of POW, representing approximately 20% of Game Management Unit 2 (GMU 2; Fig. 1). During 2014–2015, we increased the extent of our noninvasive DNA sampling area to 3,281 km^2, representing approximately 36% of GMU 2 (Fig. 1).

METHODS

Sample Collection

During autumn 2012–2015, we established an array of sampling nodes consisting of 5 hair boards (i.e., hair-snaring devices) set at 50-m spacing intervals across the study area (Fig. 1). Node spacing was roughly 3.9 ± 1.1 km during 2012–2013, and 3.5 ± 1.0 km during 2014–2015. Hair board nodes were deployed mid-October–late-December (2012, $n = 37$; 2013, $n = 36$; 2014, $n = 72$; 2015, $n = 82$). In a design modified from Ausband et al. (2011), we constructed hair boards from plywood and affixed barbed-wire and tie-wire to create snagging surfaces (Roffler et al. 2016). We

applied approximately 5 mL of commercially produced lure to the hair boards on every sampling occasion to evoke a scratch-and-rub response (Fig. 2). We stabilized boards with 16 penny nails driven through the corners of the board and into the ground and attached the boards to a flagged tree or branch with wire. Sampling intervals were 10 days in 2012 and 7 days in 2013–2015. We reduced the length of time between node checks beginning in 2013 to minimize potential genotyping error from DNA degradation (e.g., from moisture), and increase our chances of redetecting individual wolves. Hair was collected using sterilized tweezers, stored in labeled coin envelopes, and dried at room temperature. To prevent cross-contamination we used a soldering torch to sterilize hair board barbs after collecting hair samples.

Genotyping

We conducted DNA extractions, genetic identification of species, wolf genotyping, and sex identification at the National Genomics Center for Wildlife and Fish Conservation, Missoula, Montana, USA. For DNA extractions, we used 10–20 hairs, except in situations when we had evidence of >1 wolf depositing hair on the same board (multiple wolves detected in photos, multiple sets of tracks, or from very large clumps of hair collected on a board). In these cases, we implemented a single-hair DNA extraction protocol to detect multiple individuals from these samples and eliminate the chance for mixed-DNA samples, which would increase genotyping error. This protocol consisted of selecting 4 hairs with follicles from different locations in the hair clump and performing a separate DNA extraction on each hair. We extracted DNA from samples using standard protocols for tissues (DNeasy Blood & Tissue kit; Qiagen, Valencia, CA, USA) with the following modifications: overnight incubation in buffer ATL and Proteinase K on a rocker or in a rotating oven at 56° C, a 70° C incubation for 10 min after adding buffer AL, and a final elution using 100 μL buffer AE warmed to 70° C.

We first identified samples to the genus level by Sanger sequencing a portion of the 16S rRNA gene from the mitochondrial genome (mtDNA) to screen nontarget species. We amplified the 16S rDNA using conserved, universal primers 16sL 5′-TTAAACGGCCGCGGTATCC-3′ and 16sR 5′-GAATTACGCTGTTATCCCT-3′ modified from Hoelzel and Green (1992). The mtDNA analysis does not distinguish between wolves and dogs (*C. l. familiaris*), but we were able to screen dogs from the final data set after microsatellite genotyping as described in the following 3 paragraphs.

We used muscle tissue samples from wolves taken during annual hunting and trapping seasons and blood samples from 10 wolves captured during radiocollaring to design the microsatellite panel and distinguish wolves and dogs in the noninvasive sampling. These samples were not used in any of the population estimates. Ten loci were variable in our wolf population and amplified consistently in noninvasively collected DNA samples: cph5 (Fredholm and Wintero 1995); fh2096, fh2137, fh2054, fh2140, fh2161, Pez17, fh2001 (Duchamp et al. 2012); fh2079 (Francisco et al. 1996); c20.253 (Ostrander et al. 1993). We calculated the probability of identity ($P_{(ID)}$) and probability of identity for siblings ($P_{(ID)sibs}$) using GenAlEx 6.5 (Peakall and Smouse 2006).

We first amplified all canid hair DNA samples at 2 loci that amplify most consistently in noninvasive samples (cph5 and fh2096) and included 2 positive controls in each PCR. Samples that amplified consistently at one or both loci were then amplified at the remaining 8 loci (the others were discarded from further analysis). We accepted data for each sample at each locus only if the sample amplified consistently between duplicates. If amplification was inconsistent between duplicates (e.g., 3 alleles detected in one or both duplicates, allelic drop out, or false alleles), no genotype was called for that locus. We amplified samples with missing genotypes at <4 loci in duplicate at those loci. Consistent amplification was required in ≥2 amplifications before a

Figure 2. Wolf rubbing on hair-snare board, Prince of Wales Island, Alaska, USA, 2012–2015.

consensus genotype was called. We added negative controls to all steps in 2015, and contamination was not detected. We quantified genotyping error as the proportion of PCR reactions at all loci with allelic dropout or the amplification of false alleles. We quantified genotyping success rate as the percentage of samples that successfully amplified and passed quality control steps for 1) identifying individual wolves out of all the hair samples; and 2) identifying individual wolves from all the hair samples identified as canids. We used MicroChecker 2.2.3 with 1,000 randomizations to identify genotyping errors including null alleles, stutter, and allelic dropout (Van Oosterhout et al. 2004). We used DROPOUT 2.3 to identify matches of unique genotypes within and among sampling seasons (McKelvey and Schwartz 2005). We identified sex of individual wolves using the canid SRY marker (Wictum et al. 2013).

We used 2 methods using reference data from local wolves and dogs to differentiate wolves from dogs with microsatellite data. First, we conducted a principal coordinate analysis (PCoA) to visualize clustering (GenAlEx 6.5). Second, we used a Bayesian clustering procedure implemented in STRUCTURE v2.3.3 to assess the average proportion of membership of the sampled canids to either the wolf or dog clusters (Pritchard et al. 2000). We assumed 2 populations ($K = 2$) with a general admixture model and correlated allele frequencies and performed the analysis 10 times independently after a burn-in of 100,000 and 1,000,000 Markov Chain Monte Carlo repetitions.

Population Density Estimates

We used SECR models in the Program R software package SECR (v 2.9.4; Efford 2015) to estimate the density and population size of wolves in our study area (Efford 2004, Borchers and Efford 2008). We compiled spatial detection histories for wolves genetically identified from hair deposited on hair boards on multiple sampling occasions. We defined sampling occasions as the period between node checks and allowed the length to vary for each node individually based on actual node exposure time. A few nodes could not be checked during a sampling occasion because of severe snow conditions; thus, we considered the node inactive during that occasion, but we then increased the length of the subsequent occasion to account for the actual exposure time. We specified a clustered trap design, so unique detections at all 5 hair boards within a node could be used individually for parameter estimation. We fit models specifying count type detectors because multiple wolves could be detected at the same hair board during the same occasion, and the same wolf could be detected at multiple locations during the same occasion. We fit hybrid mixture models with a Gaussian detection probability function and incorporated covariates including sex and a variety of coefficients representing the effects of various behavioral responses and site-specific changes in effectiveness on detection probability and movement parameters (Pledger 2000; Table S1, available online in Supporting Information). We evaluated a suite of competing models based on information theoretic methods (Akaike's Information Criterion corrected for small sample size [AIC_c]; Burnham and Anderson 1998).

We defined a discrete habitat mask based on a 500-m grid for the study area by delineating a buffer around the trap array (based on the maximum extent of animal movement during the study period) and then clipped it to the POW shoreline (Fig. 1). The buffer was 10 km in 2012 and 2013, and 20 km in 2014 and 2015, resulting in 1,683 km^2 and 3,281 km^2 study areas, respectively. We used wolf density estimates from the study area to predict the GMU 2 (9,025 km^2) wolf abundance. We assessed significant differences ($\alpha = 0.05$) in SECR model parameter estimates between years by generating bootstrapped 95% confidence intervals of the difference between estimates on the original log scale using 5,000 replications.

RESULTS

Sample Collection

We collected 64 hair samples from hair boards in 2012, 93 in 2013, 147 in 2014, and 232 in 2015 (Table 1). The number of wolves redetected increased throughout the study period (2012: $n = 6$, 2013: $n = 8$, 2014: $n = 10$, 2015: $n = 15$). To assess the contribution of increased sampling area and intensity on success of detecting individual wolves, we compared 2014 and 2015 sampling results using all the nodes (2014: $n = 72$, 2015: $n = 82$) to results using data from only the nodes previously used in 2013 ($n = 34$; 3 nodes could not be reestablished during 2014–2015 due to road closures or construction). Trapping success (no. of wolf detections via DNA/100 trap-nights) was not greater with increased

Table 1. Number of hair samples collected, the percentage of samples successfully identified to the genus level using mtDNA, the percentage of 1) all the hair samples; and 2) the *Canid* spp. hair samples successfully identified to the individual level using 10 microsatellite loci, the number of hair samples that successfully identified individuals, the number of individual wolves identified from hair samples, and the male (M) and female (F) wolves sampled by year on Prince of Wales Island, Alaska, USA, 2012–2015. "NA" is not applicable.

Year	No. of hair samples	Genus ID success	Individual ID success	Individual ID success (canids only)	No. of hair samples ID success	No. of wolves detected	M	F
2012	64	81%	39%	67%	30	11	9	2
2013[a]	80	91%	56%	83%	45	18	8	10
2013[b]	52	NA	23%	NA[c]	12	7[d]	4	3
2014	147	71%	45%	65%	65	21	14	7
2015	232	79%	46%	78%	106	24	12	12

[a] Regular hair DNA extractions.
[b] Single-hair DNA extractions.
[c] No genus ID.
[d] Four individuals also represented in regular extractions.

Table 2. Sampling effort for spatially explicit capture–recapture estimates of wolf density using noninvasively collected wolf hair, Prince of Wales Island, Alaska, USA, 2012–2015.

Year	Total days	No. of hair-snare nodes	Wolves detected[a]	Wolves/100 trap-nights
2012	69	38	16	1.32
2013	68	37	33	1.88
2014	66	72	37	0.84
2014[b] (2013 nodes)	66	34	21	1.00
2015	76	82	56	1.09
2015[b] (2013 nodes)	76	34	23	0.86

[a] The total number of wolf detections (includes redetections).
[b] These nodes were a subset sample for comparison with the same nodes sampled in 2013.

sampling effort, but we did detect more wolves in the expanded study area in comparison to the reduced study area (Table 2).

Genotyping

Genus identification was performed on mtDNA sequences from all collected hair samples, with the exception of the 13 hair samples collected in 2013 on which we performed the single-hair extraction protocol (see third paragraph in this section). Genus identification success ranged from 71 to 91% (Table 1; Table S2, available online in Supporting Information).

Using microsatellites from the harvested wolves, the putative wolves identified from hair samples, the 59 known dogs, and the 18 suspected dogs including 2 recaptures (5 in 2012, 6 in 2013, 4 in 2014, and 5 in 2015), we demonstrated that the dogs clustered together and apart from the known wolf samples, as well as apart from the wolves identified from hair samples (Fig. S3, available online in Supporting Information). Samples from the putative dogs contained alleles at 3–6 loci that were consistent with known dogs and that we did not observe in our known wolf samples. The STRUCTURE clustering was consistent with PCoA results with dogs and wolves clearly separated (data not shown). Average population assignments were large for each group ($q = 0.99$ for both dogs and wolves). These analyses suggest the 18 individuals were dogs and not wolves; thus, they were excluded from subsequent analyses.

The 10 variable microsatellite loci produced a cumulative $P_{(\mathrm{ID})} = 5.35 \times 10^{-7}$, and $(P_{(\mathrm{ID})\mathrm{sibs}}) = 1.9 \times 10^{-3}$, providing acceptable power to identify individuals and siblings from the noninvasive samples. We used the microsatellite panel to genotype hair samples identified as canids. Genotyping error occurred in 3.3% of the first duplicate reactions at all loci, and 2.9% in a rerun of a second duplicate. The genotyping success rate (the percentage of samples that successfully amplified and passed quality control steps) of identifying individual wolves out of the regular extractions for all hair samples ranged from 39 to 56%. The genotyping success rate of identifying individual wolves from only the canid hair samples ranged from 65 to 83% (Table 1). The single-hair extraction samples had a considerably lower genotyping success rate for identifying individuals at 23%, although 7 individuals were identified (4 were represented in the standard hair extraction samples, and 3 were previously undetected wolves; Table 1).

During the time period of the hair board sampling, 57 wolves were identified from noninvasively collected hair samples. Nine wolves were detected across sampling years from hair samples; 4 of 24 wolves detected in 2015 had been previously detected in 2013 and 2014. The 8 redetected wolves in 2013 consisted of 4 individuals detected twice, and 4 individuals detected 3 times. The 10 redetected wolves in 2014 included 5 individuals detected twice, 3 individuals detected 3 times, and 2 individuals detected 6 times. Of the 13 redetected wolves in 2015, 6 individuals were detected twice, 4 individuals were detected 3 times, and 2 individuals were detected 4 times, and 1 individual 6 times. The distance between sequential redetections at hair board nodes in 2013 ranged from 0 (recaptured at same node where originally detected) to 27.7 km (mean distance = 2.9 ± 5.9 km); whereas, in 2014, distances moved were larger (range = 0–29.6 km; mean distance = 17.9 ± 1.6 km). In 2015, the maximum distance moved between a consecutive redetection was large, though the average distance was smaller than in 2014 (range = 0–41.7 km, mean 8.4 ± 10.4 km).

We did not detect allelic dropout or stuttering in the microsatellite loci, but 2 of the 10 loci (fh2137 and fh2001) demonstrated a significant probability of homozygote excess (in one of 11 and one of 10 alleles, respectively) signifying the possibility of null alleles. Inbreeding can also contribute to development of homozygote excess; therefore, we used Null Allele Estimator 1.3 to account for the bias of inbreeding in null allele estimates (Van Oosterhout et al. 2006). Using estimates of inbreeding ($F_{IS} = 0.051$; described below), we determined the frequency of null alleles was 0.012 across all 10 loci and thus we retained them for further analyses.

Population Density Estimates

Sampling during 2012 resulted in an insufficient number of redetections of individual wolves from hair samples for a reliable population density estimate (only 5 wolves were redetected after initial detection). The density estimate from the autumn 2013 top-ranked SECR model was 24.5 ± 6.8 wolves/1,000 km^2 (95% CI = 14.4–41.9 wolves/1,000 km^2; CV = 0.278; Table 3). This model included a sex-specific coefficient on both the baseline detection probability parameter (g_0) and the range parameter (σ), which is related to, and proportional to, the size of the home range. The top-ranked model for 2013 also incorporated a site-effectiveness coefficient (k) on g_0. This term indicated that the probability of detecting an animal at a given location increased by 4.7 ± 1.5 times after the first detection (i.e., the site became more effective). Using the density estimate from the top-ranked model, the estimated autumn 2013 population size of the study area (1,683 km^2) was 41.3 ± 11.7 wolves (95% CI = 24.0–71.2), and the predicted population size for GMU 2 was 221.1 ± 61.4 wolves (95% CI = 130.0–378.1).

The density estimate for autumn 2014, based on the top-ranked model, was 9.9 ± 3.0 wolves/1,000 km^2 (95% CI = 5.5–17.7 wolves/1,000 km^2; CV = 0.304; Table 3). This

Table 3. Comparison of density estimates of autumn wolf population, based on the most parsimonious spatially explicit capture–recapture hybrid mixture model using data from the full sampling node array, and the truncated array (using sampling nodes established in 2013), 2013–2015, Prince of Wales Island, Alaska, USA. Predicted wolf population estimates for Game Management Unit (GMU) 2 (9,025 km^2) are shown. SE, standard error; CI, confidence interval.

			Density (per 1,000 km^2)			GMU 2 expected $\widehat{N}$
Year	No. of nodes	Area (km^2)	Density ± SE	95% CI	CV_D	$\widehat{N} \pm$ SE
2013	37	1,683.8 km^2	24.5 ± 6.8	14.4–41.9	0.278	221.1 ± 61.4
2014 (all nodes)	72	3,280.9 km^2	9.9 ± 3.0	5.5–17.7	0.304	89.1 ± 27.1
2014 (2013 nodes)	34	1,689.4 km^2	10.7 ± 4.1	5.2–21.9	0.383	96.5 ± 35.2
2015 (all nodes)	82	3,281.1 km^2	11.9 ± 2.7	7.7–18.5	0.228	107.5 ± 24.4
2015 (2013 nodes)	34	2,463.6 km^2	17.0 ± 10.5	5.0–57.6	0.621	153.7 ± 95.6

estimate was significantly lower than the previous year. In contrast to 2013, where the top model accounted for 100% of the AIC_c weight, there were several competing models for 2014. The top-ranked model for 2014, which had an AIC_c weight of 0.378, also contained a site-effectiveness term on the baseline detection probability and indicated an increase in $\widehat{g}_o$ of 4.9 ± 1.6 times after the first detection at a given location. Using the density estimate from only the top-ranked model, the predicted number of wolves in the 2014 extended study area (3,281 km^2) was 32.4 ± 10.1 (95% CI = 17.9–58.7) and 89.1 ± 27.1 (95% CI = 49.8–159.4) for GMU 2.

The density estimate from the autumn 2015 top-ranked SECR model was 11.9 ± 2.7 wolves/1,000 km^2 (95% CI = 7.7–18.5 wolves/1,000 km^2; CV = 0.228; Table 3). The top 5 population estimate models for 2015 wolf density in the study area resulted in similar estimates and all contained either a site-effectiveness (k) or site-specific behavioral change (bk) coefficient on g_0. Using the density estimate from the top-ranked model to predict the number of wolves in the extended study area (3,281 km^2) resulted in an estimate of 42.5 ± 6.3 wolves (95% CI = 33.7–59.6), and a population estimate in GMU 2 of 107.5 ± 24.5 wolves (95% CI = 69–167). This estimate is significantly greater than the autumn 2014 estimate.

To examine effects of expanding the study area and sampling intensity in 2014, we fit models with the same parameter specifications using a reduced data set containing information only from nodes that had also been deployed in 2013. Similar to 2013, a 10-km buffer was used based on an analysis of the animal movements among the reduced set of nodes. The top-ranked model using the reduced data set was similar to the top-ranked full-data model, except that the site-effectiveness term was a transient response (K) where the change in site effectiveness depends on the preceding occasion, rather than a change that persisted throughout the remainder of the study period. The density estimate using this model was greater (10.7 ± 4.1 wolves/1,000 km^2, 95% CI = 5.2–21.9 wolves/1,000 km^2) than the top-ranked full-data model (9.9 ± 3.0 wolves/1,000 km^2), but not significantly so (Table 3). The predicted population in the study area based on this density estimate was comparable to that defined in 2013 (i.e., with a 10-km buffer) of 18.1 ± 6.8 wolves (95% CI = 8.8–36.9). Using this density estimate to predict the 2014 population size for GMU 2 resulted in an estimate of 96.5 ± 35.2 wolves (95% CI = 48.3–193.0; Table 3). Increasing the size of the study area and the density of nodes resulted in a density estimate with a substantially lower coefficient of variation for the estimated density parameter (0.304 vs. 0.383).

A similar analysis was performed for the 2015 data; however, a 20-km buffer was used because of some extremely large movements made by a small subset of animals. The formulation of the top-ranked model for the reduced data set (using information only from the nodes deployed in 2013) was the same as the top-ranked model using the full data set. The density estimate produced using this top-ranked model with the reduced data set was greater (17.0 ± 10.5 wolves/1,000 km^2, 95% CI = 5.0–57.6 wolves/1,000 km^2) than the full-data model (11.7 ± 2.7 wolves/1,000 km^2; Table 3). Using the reduced-data-set density estimate, the GMU 2 population size was predicted to be 153.7 ± 95.6 wolves (95% CI = 50.1–471.4); however, precision was low (CV = 0.621; Table 3). Therefore, expanding the study area and the density of nodes in 2015 (compared with 2013) resulted in a much more precise population estimate.

DISCUSSION

Our objective was to assess the use of a noninvasive sampling and SECR approach to estimate abundance of wolves over a multiyear period in a dense rainforest environment. We conducted this research to evaluate whether this method would be more reliable (produce stable and consistent measurements), efficient (high output to effort and cost ratio) and precise (low variation between measurements) than the radiocollaring and observation method used in the early 1990s (Person et al. 1996), which we used concurrently with the noninvasive method during 2012–2015 to estimate the POW wolf population. Autumn population sizes were estimated using 1) empirical estimates using an adjusted minimum count; and 2) a territory mapping model that accounted for size of packs and territories (Person et al. 1996, Roffler et al. 2016). The minimum count method does not have an associated measure of precision. The precision of the territory mapping model estimate (CV = 0.432–0.895) was lower than the SECR population density estimate (CV = 0.228–0.365), reducing its utility in detecting changes in the population among years. A further limitation of the territory mapping method was that it was not robust to violations of model assumptions (all available space is occupied by wolf packs, the proportion of wolves in the study area not associated with a pack is consistent; discussed in

Roffler et al. 2016). Counting wolves during aerial telemetry proved to be unreliable because only one-third of the completed flights produced any visual observations of wolves (Roffler et al. 2016). Although data from radiocollared wolves did not prove to be suitable for annual population estimates on Prince of Wales Island, we were able to obtain beneficial information including Global Positioning System location data for assessing seasonal home range sizes, habitat selection, and variation in space use surrounding dens sites (Roffler et al. 2018, Roffler and Gregovich 2018).

Our criteria for evaluation of the noninvasive population estimation method were based on the potential application to long-term monitoring of wolves in densely forested areas. There were several unique challenges encountered while implementing this method in our study area; thus, successful application in other study systems will require careful consideration of these issues. This research represents one of the first attempts to estimate wolf population density using SECR, so further work is required on POW and in other areas for comparison and further method refinement (López-Bao et al. 2018).

Noninvasive methods may be less effective in wet environments; thus, we needed to assess the feasibility of recapturing wolves using DNA from noninvasive samples considering the copious annual precipitation in our study area. Excessive rainfall had been attributed to reduced DNA amplification success using canid scat samples and can result in partial or total removal of the sample from the environment due to the dissolving effect of rain (Morin et al. 2016). Preliminary efforts to initiate this study in 2009–2011 involved attempts to locate wolf scats and amplify DNA for individual genotypes. This effort was not successful because of the low number of fresh wolf scats encountered on road surveys and limited individual genotyping success of degraded samples (D. Person, unpublished data). Rainfall also reduces genotyping success in noninvasive hair samples. For example, Stansbury et al. (2014) demonstrated individual identification success rates using DNA from wolf hair was relatively lower in the wetter section of their study area (71 cm annual precipitation) in comparison to the area that received less precipitation. We took precautions to improve our ability to amplify wolf DNA from hair; we reduced the number of days between hair-snare station checks from 10 days (in 2012) to 7 days and were cautious to air dry samples immediately after collection. Dumond et al. (2015) also found a negative relationship between genotyping success rate using noninvasively sampled bear hair and the number of rainy days between sampling sessions. Therefore, we recommend limiting the interval between sampling sessions to $\leq$7 days in very wet environments, similar to noninvasive DNA sampling-interval recommendations for deer pellets in temperature rainforests (Brinkman et al. 2010).

After initial difficulties in 2012 obtaining enough redetections for a reliable density estimate, we augmented sampling effort by increasing the number of sample occasions, the number of sampling stations, and the total sampling area. These efforts contributed to obtaining sufficient individual redetections during 2013–2015 to estimate population density. Success of this method was dependent upon obtaining enough spatial redetections; therefore, trap spacing was a key consideration and considered one of the most important design elements in a spatial capture–recapture study (Royle et al. 2014). The ideal study design will balance objectives of obtaining a large number of individuals sampled and a large number of spatial recaptures (Wilton et al. 2014). Resources to conduct fieldwork are finite, so sampling over a larger area translates to lower trap density, which is a scenario that results in more unique individuals captured but fewer spatial recaptures (which causes imprecise and biased density estimates). The reverse scenario (smaller area sampled with greater trap density) results in fewer unique individuals captured, but more spatial recaptures (which causes imprecise density estimates). Results of simulation studies to assess effects of study design on population estimate bias and precision indicate that the optimal trap spacing is $1.5–2.5 \times \sigma$ (Sollmann et al. 2012, Royle et al. 2014).

The social behavior of wolves contributed to deposition of 13 mixed samples (i.e., hair from >1 wolf) at some of the hair boards in 2013. Mixed samples may have 3 alleles amplify at a locus, and thus have low individual identification genotyping success. Therefore, this is a situation that should be considered, particularly when obtaining a sufficient number of recaptures is challenging because of the scenarios described above. Single-hair catch devices have been implemented in noninvasive monitoring of other species and are useful in eliminating mixing of individual hair samples (Beier et al. 2005, Stricker et al. 2012). However, pilot efforts to develop single-catch hair snares for wolves in southeastern Alaska had limited success in field trials (L. Beier, Alaska Department of Fish and Game, unpublished data). In the absence of a reliable single-catch device, we instead resolved the issue of mixed samples by implementing genotyping screening, wherein hair samples that were suspected to consist of >1 individual were analyzed separately using the single-hair DNA extraction protocol. This procedure resulted in an increased genotyping success rate from 66% in 2012 to 83% in 2013. Photos from trail cameras located at hair board stations did not detect multiple wolves when the samples were deposited in 2014–2015.

Temporal and spatial scales are necessary to consider when using noninvasive spatial capture–recapture methods to estimate large carnivore abundance. One temporal consideration is the seasonal behavior of the study species. We designed the sampling period to coincide with the season of increased mobility of wolves, as pups become large enough to travel in the autumn and less constrained to den and rendezvous sites. When den or rendezvous site locations are known, it is possible to obtain shed hair and scat for individual genetic identification for multiple wolves in a pack including pups (Stenglein et al. 2010, Stansbury et al. 2014). Sampling pups from snared hair obtained from snagging devices is likely more feasible when pups are larger and more mobile. We also considered seasonal attributes of the study system when establishing the sampling design. We expected, as the season progressed into late autumn and early winter,

that fewer bears would be present in the landscape; thus, we could minimize nontarget hair samples or mixed species samples, which do not produce an individual genotype. Despite accounting for seasonal presences of bears, we still obtained 15–25% of bear hair in the samples, although it is probable that summer sampling would result in a larger proportion of bear hair.

The total sampling duration and the number of sampling occasions of a study period is an important design consideration in spatial capture–recapture studies. We designed the time frame of our sampling period to address a need for annual population estimates at the management-unit level, which provide the basis for establishing wolf harvest quotas (based on 20% of the estimated GMU 2 wolf population). We found that within our study system, we collected enough data for a population estimate during a 9–10-week period. However, it is necessary to account for the time required for DNA extraction and individual genotypes to become available for SECR analyses. This process may be time-consuming; so "real-time" population estimates are less possible with noninvasive sampling in comparison to visual surveys of radiocollared animals. Despite this drawback, we were able to provide information for harvest management for the subsequent year (the Federal subsistence wolf hunting season begins in GMU 2 on 1 Sep, and trapping season begins on 15 Nov) by using the population estimates and accounting for known removals (wolves harvested after the sampling was complete).

The ideal total sampling duration of a study period is a trade-off between collecting enough spatial recaptures during the sampling occasions, with an attempt to do so in an abbreviated time period to avoid violations of the assumption of demographic closure. Our study occurred during the beginning of the annual hunting and trapping seasons, so mortalities occurred within our study area during the sample collection period. Known removals of marked animals can be incorporated into the model to eliminate this source of bias, but removals of unmarked animals or unrecorded removals would result in a positive bias in the density and population size estimates. No animals were reported as being taken by hunters or trappers from the study area during the 2014 or 2015 sampling periods; however, 2 known animals were removed during the 2013 study period. Satisfying assumptions of complete demographic closure are difficult in highly mobile species and dynamic populations; therefore, potential approaches to resolve this issue include reducing the sampling period, or planning the sampling period outside of the harvest season, which in GMU 2 extends until 31 March.

Spatial capture–recapture models are able to accommodate a variety of sampling designs at different spatial scales. The extent of the study area is flexible and depends on the study question, biological characteristics of study species (e.g., home range size and movement patterns), and practical considerations such as available resources and access to trap locations. Unlike nonspatial capture–recapture methods, it is not necessary for the trap array to extend over an area many times larger than the average home range of the focal species (Sollmann et al. 2012). Therefore, spatial capture–recapture is suitable for estimating abundance of wide-ranging carnivores. In practice, the state-space (the region that defines possible values of activity centers) should contain all individuals that may be captured, and the area surrounding the trap array for estimating abundance from density is buffered by $3 \times \sigma$. The study-area extent may vary in size from an area as small as an individual home range to large spatial scales at the landscape level, as long as the main objective of the study design is to sample as many unique individuals in different locations as possible, which will result in more precise parameter estimates (Efford 2004, Sollmann et al. 2012, Royle et al. 2014). Considering the mobility and territoriality of many carnivore species, it is necessary to establish a study area that encompasses the home ranges of many individuals or packs (in the case of social carnivores). Like many management agencies, the ADF&G and the USFS manage wolves at the management-unit level for harvest seasons and bag limits, so it is desirable to estimate abundance at this spatial scale. Other spatial capture–recapture studies have been conducted at broader scales, such as at a regional or provincial level (Morehouse and Boyce 2016, Humm et al. 2017, López-Bao et al. 2018). One option that may enable increasing study area size without increasing the number of traps is cluster sampling, which may help overcome practical limitations such as availability of finite resources, and access to sampling sites (discussed in Royle et al. 2014, Sun et al. 2014).

MANAGEMENT IMPLICATIONS

In GMU 2 wolf populations are managed largely through hunting and trapping regulations (seasons and harvest quotas) based on regulations established by the Alaska Board of Game (for residents and nonresidents) and by the Federal Subsistence Board (for qualified subsistence users on Federal lands). These regulations have been based on a proportion of the total estimated population since 1997 and have ranged from 20 to 30%. Currently, the harvest guideline level is 20% of the autumn population estimate, but it is expected that the Board of Game could raise the harvest limit if the GMU 2 wolf population demonstrably increases. Until this study, there have not been regularly completed wolf population estimates; thus, in the absence of population trend data, harvest decisions have been based on the 1994 population estimate and local knowledge of residents and biologists. In GMU 2, wolf harvest is managed more conservatively than in other parts of Alaska because of conservation concerns of the wolves on Prince of Wales Island. Therefore, regular monitoring of abundance is necessary to ensure the wolf population remains available for sustainable use, as is the mandate of ADF&G. Our results offer an effective method to gain population abundance estimates of widely ranging carnivores at the management-unit level and on an annual basis for regular monitoring and to inform management strategies.

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SUPPORTING INFORMATION

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Table S1. Definition of predictor variables used in spatially explicit capture–recapture (SECR) hybrid mixture models to estimate wolf density, 2013–2015, Prince of Wales Island, Alaska, USA.

Table S2. Number of hair samples successfully identified to the genus level using mtDNA and identified as *Canis* sp., black bears (*Ursus americanus*), marten (*Martes americanus*), nontarget species, or mixed samples, Prince of Wales Island, Alaska, USA, 2012–2015.

Figure S3. Principal coordinate analysis (PCoA) results of pairwise, individual codominant genetic distances using the standardized covariance matrix option to distinguish between wolf (using hair, blood and muscle tissues) and putative dog (using hair) samples. Results were used to visualize genetic clusters based on 10 microsatellite markers. The first and second PCoA axes accounted for 18.38% and 7.95% of the genetic variation, respectively.

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Author(s): http://orcid.org/0000-0002-8534-3664Gretchen H. Roffler and David P. Gregovich
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Wolf space use during denning season on Prince of Wales Island, Alaska

Gretchen H. Roffler and David P. Gregovich

G. H. Roffler (http://orcid.org/0000-0002-8534-3664) (gretchen.roffler@alaska.gov) and D. P. Gregovich, Alaska Dept of Fish and Game, Division of Wildlife Conservation, 802 3rd Street, Douglas, AK 99824, USA.

Wolf *Canis lupus* reproductive success may be enhanced by access to favorable habitat with limited disturbance during denning season. Therefore, protection of den sites can be an important management strategy for maintaining viable wolf populations. On Prince of Wales Island in southeast Alaska, USA, management agencies recommend protection of dens and surrounding home ranges. However, these agencies are concerned current protection buffer sizes might be inadequate to promote pup-rearing success. To inform management decisions regarding buffers surrounding wolf dens, we used wolf GPS collar data during 2012–2016 to quantify core and home range area sizes during denning season. We used an autocorrelated kernel density estimator (AKDE) to calculate the extent of home ranges and fit individual wolf movement models. Breeding wolves used smaller core (AKDE 50% isopleth = 6 km^2, SD = 4 km^2) and home range areas (AKDE 95% isopleth = 57 km^2, SD = 17 km^2) during denning season (15 April–15 June) than non-breeding wolves at active dens (core = 69 km^2, SD = 45 km^2; home range = 252 km^2, SD = 161 km^2). Home ranges for breeding wolves and wolves belonging to a reproductive pack were smaller than non-breeding wolves throughout the pup-rearing period (15 April–31 July). The mean minimum and maximum distance from the core area edge to the active den site (1186–6326 m) varied widely but was smaller for breeding wolves (734–2308 m), and all distances exceeded the existing recommended den buffer distance (366 m). These results underscore the importance of evaluating individual variation in space use when considering management actions intended to protect cooperative breeders or other social carnivores. Wolf managers should recognize the current protection buffer around dens constitutes only a portion of the core area used by breeding wolves, and habitat alterations near den sites may force breeding wolves to use sub-optimal habitat they would normally avoid.

Keywords: *Canis lupus*, wolf, dens, home range, pup rearing

Wolves *Canis lupus* exhibit large variation in home range sizes, which is influenced by many factors including wolf density, prey abundance, habitat quality, reproductive status and season (Fuller et al. 2003, Hinton and Chamberlain 2010, Mattisson et al. 2013, Kittle et al. 2015). During denning season, wolf home ranges are constrained because wolf activity is focused around the den site (Jędrzejewski et al. 2001, Ruprecht et al. 2012). Pups are most vulnerable during the first 6 weeks of life due to reduced mobility (Mech and Boitani 2003, Mills et al. 2008), thus wolves generally locate den sites in areas protected from exposure to disturbance (e.g. human settlements, Sazatornil et al. 2016, Llaneza et al. 2018) or less visible due to landscape features or vegetation cover (Trapp et al. 2008; but see Matteson 1992 and Unger 1999). Den sites have ecological importance because survival of wolf pups is most variable during early denning season through late summer, and this component of reproductive success has a large effect on the demographic trajectory of the population (Harrington and Mech 1982, Ballard et al. 1987, Fuller et al. 2003, Benson et al. 2015). Because wolf pup rearing occurs at these sites, reproductive success may be enhanced by access to favorable habitat with limited disturbance during denning season (Sazatornil et al. 2016) as relocating pups may increase risk of mortality (Ausband et al. 2016). However, other studies indicate that in some circumstances wolves can be tolerant of human disturbance during denning season (Chapman 1977, Thiel et al. 1998), and even relocation of pups as a result of disturbance has not caused a negative impact to reproductive success (Frame et al. 2007). Variability in the degree of tolerance wolves display to disturbance underscores the need for more refined information on space use requirements during the denning season, which could help inform management efforts to minimize anthropogenic disturbance where and when it is necessary.

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Wolves in southeast Alaska have been a focus of conservation efforts since the mid-1990s, triggered by concerns over the negative ecological consequences of old-growth logging on wildlife habitats, increased human-caused wolf mortality facilitated by access via logging roads (Person et al. 1996, Person and Russell 2008, Person and Brinkman 2013), and later by decreases in wolf density on Prince of Wales Island (POW) over the past two decades (Person et al. 1996, Roffler et al. 2016). Conservation concerns have been focused on Prince of Wales Island (POW; Fig. 1), as it is estimated to harbor approximately one third of the southeastern Alaskan wolf population (Person et al. 1996), and also has the highest rates of logging in southeast Alaska with an extensive road system (Albert and Schoen 2013, Person and Brinkman 2013). On three occasions the US Fish and Wildlife Service has conducted 12-month Endangered Species Act reviews (USFWS 1995, 1997, 2016) of the Alexander Archipelago wolf *Canis lupus ligoni*. Although listing was determined to be not warranted for all decisions, the need for improved management of wolf harvest and habitats was outlined as a critical component to maintaining viable populations of wolves.

The US Forest Service (USFS) manages the majority of southeast Alaska lands and along with the US Fish and Wildlife Service and Alaska Dept of Fish and Game (ADF&G), through the Wolf Technical Committee has recently developed recommendations to maintain sustainable populations of POW wolves (Wolf Technical Committee 2017), a management indicator species in the Tongass National Forest Land and Resource Management Plan (USFS 1997, 2008, 2016). Management recommendations include enhancement of the habitat of POW wolves' primary prey, Sitka black-tailed deer *Odocoileus hemionus sitkensis* through forage enhancement and protecting old-growth forest and restricting human-caused mortality of wolves through management of road access and harvest regulations. A primary recommendation was to protect wolf dens to avoid disruption of reproductive activities. The Wolf Technical Committee was specifically concerned the guidelines in the current Forest Plan to provide a forested

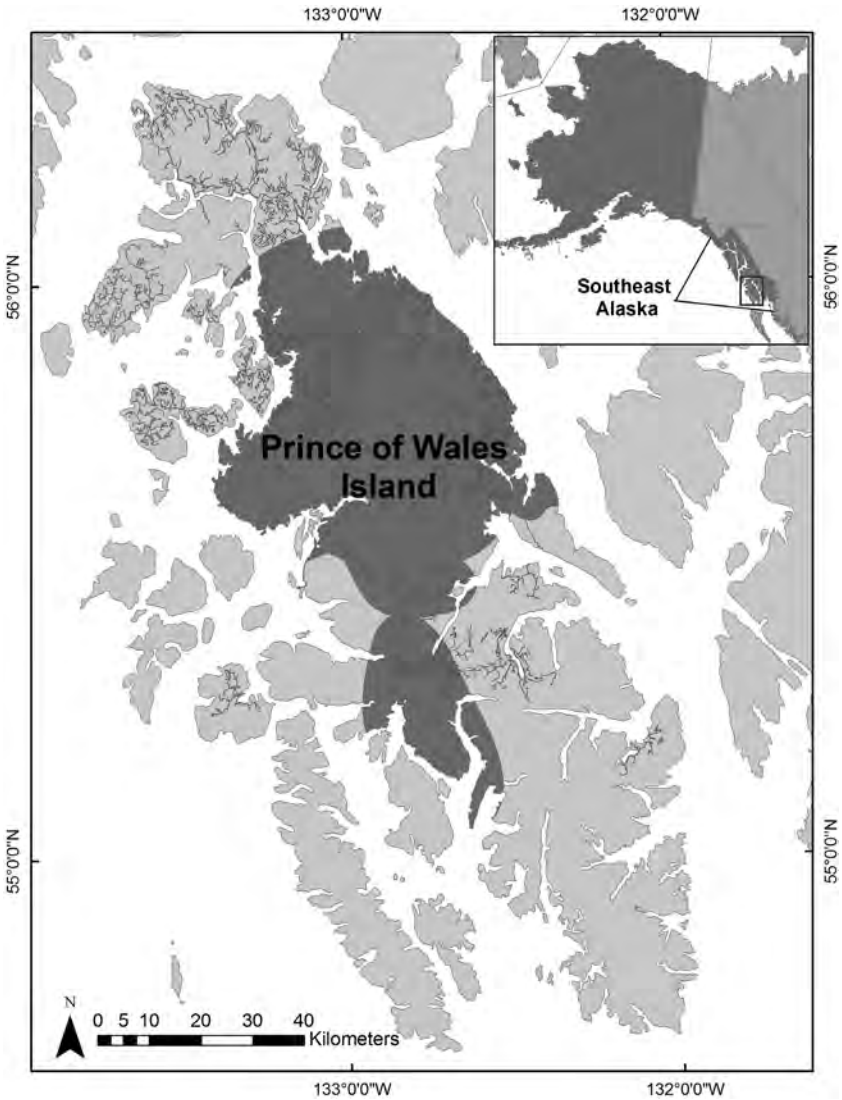

Figure 1. Wolf space use study area, Prince of Wales Island, Alaska, USA, 2012–2016. Composite home range area (combined home ranges of 13 wolves) during the denning period (15 April–15 June) is shown in dark grey, roads shown in black.

buffer around den sites where road construction is discouraged (currently 1200 feet [366 m]) may not be adequate to ensure successful breeding at a den site. In addition, the committee also recommended protecting all documented wolf dens indefinitely, which was a change from only protecting dens that were active (Wolf Technical Committee 2017).

On POW, wolves select den sites in low elevation, flat terrain, in old-growth forests adjacent to open habitats (e.g. meadows and muskegs) and freshwater streams or lakes, and avoid high density road areas (Person and Russell 2009, Roffler et al. 2018). The recently revised management recommendations endorsed permanent protection of den sites and adequate surrounding habitat (where foraging and other activities occur) to allow for pup-rearing success (Wolf Technical Committee 2017), but the Wolf Technical Committee delayed defining specific den buffer distances and the proportion of old-growth habitat (considered to be important for deer and wolf denning habitat; Wallmo and Schoen 1980, Person 2001, Person and Russell 2009) to be maintained within foraging areas pending development of and evaluation of new information. We conducted this research to provide more detailed information to the Wolf Technical Committee regarding den site habitat use of wolves which could be used to better inform protection of den sites.

In this study we assessed wolf den site habitat use and seasonal home range sizes. Our first objective was to quantify the size of core areas around each den site. We conducted these analyses specifically to provide information requested by the Wolf Technical Committee including the maximum and minimum distances from the core area boundary to the den. Our second objective was to quantify the size of home range areas around the den site, and then within each home range to assess habitat characteristics, specifically the proportion of old-growth forest in relation to other land cover categories, and distance of den sites to roads. The third objective of this study was to quantify seasonal (pup-rearing, late summer, fall, late winter) home range sizes of individual wolves and wolf packs, and to examine the relationship between individual home range size and wolf characteristics (individual identity, wolf pack membership, sex, breeding status, association with an active den) and temporal characteristics (season and year). We used wolf GPS collar data collected at shorter intervals than VHF radio collars used in previous wolf research on POW, and thus we were able to assess movement patterns and calculate home ranges during the abbreviated denning season, which were not previously possible. The research will provide information to guide long-term management of wolf den sites in forested environments and ecological insight regarding variation in seasonal space use and behavior.

Material and methods

Study area

Our study area was located on POW, the largest island (6670 km^2) in the southeast Alaska Archipelago (Fig. 1). Temperate rainforests dominated by Sitka spruce *Picea sitchensis* and western hemlock *Tsuga heterophylla* are the major land cover and were interspersed with even-aged forest stands at varying successional stages resulting from clearcut logging. Muskegs, marine estuaries, riparian and alpine zones are non-forest habitat types on POW. Our study area was focused in north-central POW, an area with extensive industrial-scale logging and approximately 4800 km of logging roads (densities in northern POW 0–4.44 km km^{-2}; Roffler et al. 2018). Wolf density on POW and the surrounding islands ranged from 39.5 wolves/1000 km^2 in 1994 to 9.9–25.5 wolves/1000 km^2 during 2013–2016 (Roffler et al. 2016).

Captures and monitoring

We captured and radiocollared wolves during 2012–2016 using methods described previously in Roffler et al. (2018). Briefly, we used modified padded long spring and unpadded coil spring foothold traps with commercially-produced lures and canid urine used as attractants. Restrained wolves were chemically immobilized (using either tiletamine HCl and zolazepam HCl, or a combination of ketamine and medetomidine) and fitted with a spread-spectrum, GPS radio collar (Mod 4500, Telonics, Inc.). All capture and handling procedures were approved by the State of Alaska Animal Care and Use Committee. The GPS collars obtained a location every 6 h during January–August, and every 2 h September–December, which were thinned to every 6 h for consistency. Collars automatically released after 24 months.

We used GPS location data to detect active den sites. Putative active dens were first identified by examinations of collared wolf locations that were geographically focused in a restricted area during the period of time previously identified as the parturition period (between the last week of April and the second week of May; Person and Russell 2009). We also visited den sites 3–6 weeks after suspected parturition to verify pup production by visual observation. We approached sites on foot in groups of 1–3 people and recorded observations of wolves when they were seen or heard. We searched the area around the den entrances for signs of fresh wolf scat, hair, scrapings or other sign. We observed the den for wolf pups but limited our time in the area to < 1 h to avoid excessive disturbance of breeding wolves. Despite these efforts, 3 wolf packs relocated their pups to a nearby den (<0.5 km) during the study period. In 2 of these cases, additional visits were made by agency employees to the den after our field visits to observe pups, and in one case low-level helicopter flights for logging activities began immediately before the relocation event (Roffler et al. unpubl.). Person and Russell (2009) also reported a low number of relocations in response to human visits to den sites. In addition, we annually visited 26 dens previously recorded by Person and Russell (2009) during 1995–2004, using the same timing and techniques to make observations of wolves at historic dens.

We established remotely triggered motion-detecting cameras at den sites (Reconyx HC600, Reconyx, Inc. Holmen, WI, or Moultrie M990i, Moultrie Products, Alabaster, AL) and reviewed images to verify the presence of pups. Cameras were established 15–30 m from the den. Timing of den occupancy was determined by reviewing the GPS location data. Wolves were considered associated

with a den site during the period of time they had locations consistently (≥2 locations within a 5-day moving window) within 200 m of the verified den location. Breeding females were identified visually during handling or in photos from cameras at den sites by evidence of lactation (Mech et al. 1993), or behavior at the den site (e.g. nursing pups, Mech and Boitani 2003). One breeding male was identified as the only male member of the pack and by den site behavior. Non-breeding wolves were adult (≥2 years old) members of the pack that did not display evidence of pup-rearing or dominant behavior identified visually from camera photos or observations.

Home range estimation

To determine the area of use around wolf dens, we first examined space use focusing on the early denning period (15 April–15 June), including the parturition period until pups are 6 weeks old. We calculated home ranges for individual wolves and used the 50% contours to define the core area, and 95% contours to define the broader home range around each den site (Benson and Patterson 2015, Hinton et al. 2016).

We then quantified seasonal home range sizes throughout the year of individual wolves and wolf packs using 95% contours. We established four home range seasons based on wolf life history and previous research conducted in the study area (Person and Russell 2009, Roffler et al. 2018). The pup-rearing season (15 April–31 July) encompassed both the denning season and the period of time that wolf packs begin to move to rendezvous sites. During late summer (1 August–14 October) pups become more mobile and the pack activity center shifts to rendezvous sites and salmon spawning areas (Person 2001). Fall (15 October–31 December) is a period of higher mobility as pups and adults make larger movements throughout their home ranges. Late winter (1 January–14 April) includes the breeding season and is also a period of increased territorial behavior (Mech and Boitani 2003). We used data only from resident radiocollared wolves in our analyses, and therefore excluded locations of wolves during extraterritorial forays (temporary movements outside of a home range that are markedly separate from their previous locations; Ballard et al. 1997, Burch et al. 2005), or dispersal (a permanent movement away from the natal pack home range, or did not remain in one home range area for > 14 days; Person and Russell 2008).

We used an autocorrelated kernel density estimator (AKDE; Fleming and Calabrese 2017) to calculate home ranges, conducted using the ctmm 0.3.2 package (Calabrese et al. 2016, Fleming and Calabrese 2017) with R ver. 3.3.2 software (<www.r-project.org>). The AKDE method uses a semi-variance approach to account for the inherently autocorrelated nature of relocation data, as locations close together in time are also close together in space. AKDE fits a movement model to the location data to estimate the autocorrelation structure, which is then used to derive the optimal bandwidth. Standard methods that do not account for autocorrelation generally underestimate home range size (Fleming et al. 2015).

Following the steps to create AKDEs outlined in Calabrese et al. (2016) we first visually fit a semi-variogram function to the variogram of each individual wolf's movement data. We then fit isotropic (general movement patterns) and anisotropic (directional) versions of movement model types appropriate for our location data (independently identically distributed [IID], Ornstein–Uhlenbeck [OU], and Ornstein–Uhlenbeck foraging [OUF]) and selected the top-ranked model via Akaike's information criterion corrected for small sample sizes (AICc) via the ctmm function ctmm.select. The IID model assumes uncorrelated locations and velocities (equivalent to kernel density estimation), whereas the OU and OUF models describe a tendency of directed movement towards a central location (e.g. the center of a home range). OU and OUF models both describe a restricted space use process (e.g. residency in a home range) but are distinguished in that velocities are uncorrelated with OU, whereas velocity is correlated with OUF (Calabrese et al. 2016). Both the OU and OUF models estimate home range size and the position autocorrelation time, typically interpreted as home range crossing time. We averaged the probability density functions from the utilization distributions of each of the individual radiocollared wolves in a pack to obtain the home range for each pack (C. Fleming pers. comm.).

We also calculated seasonal home ranges for each wolf pack using 95% minimum convex polygons (MCP; Mohr and Stumpf 1966) with the rhr package (Signer and Balkenhol 2015) in R. We included MCP seasonal home range calculations only for comparisons with previous wolf home range estimates in our study area and elsewhere. All analyses were conducted using AKDE-calculated home ranges. All seasonal home ranges and core use areas were clipped to the shoreline of POW.

Data analyses

Core and denning home range area

We tested for differences in size of core and denning home range areas between 1) breeding wolves, 2) non-breeding wolves associated with an active den, and 3) wolves not associated with an active den using analysis of variance (ANOVA) with Tukey's post hoc tests ($\alpha = 0.05$). We lacked a sufficient sample size to test for differences between male and female breeding wolves. To measure core use of denning areas, we measured the shortest and longest distances from the active den site to the edge of the core area polygon for individual wolves associated with the active den site (Fig. 2). We measured straight line distance from all active den sites observed during our study period to the nearest open road. We used ArcMap 10.2.1 (ESRI, Redlands, CA) to conduct all spatial analyses.

To assess the quantity of old-growth habitat within denning season home ranges we calculated the proportion of old-growth forest in relation to other forest and land cover categories. Land cover spatial data development is described in Roffler et al. (2018). Old-growth forest was >150 years old. Medium- and high-volume old-growth forest were combined and evaluated as a separate category from low-volume old-growth forest because they have a higher value to deer as winter habitat (Suring et al. 1993). Young clearcuts were classified as ≤ 30 years since cut, and were characterized by the occurrence of understory shrubs, whereas old clearcuts were classified as > 30 years since cut, with dense canopies

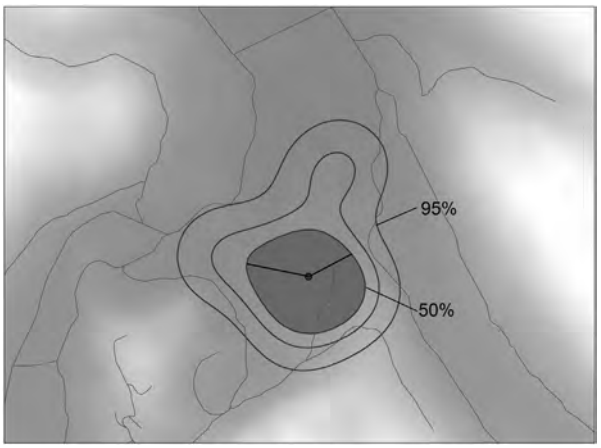

Figure 2. Schematic of core use area (AKDE 50% isopleth) and home range area (AKDE 95% isopleth) estimated with autocorrelated kernel density estimators (AKDE) during denning season (15 April–15 June), Prince of Wales Island, Alaska, USA. The core use areas around dens (gray dot) were quantified by measuring the shortest and longest distances (black lines) from the den site to the edge of the 50%isopleth.

and low occurrence of understory shrubs (Farmer and Kirchhoff 2007). The thinned forest category was comprised of young forest stands (mean age at the time of treatment was 24 years) that had been precommercially treated with thinning over >50% of their area to lower tree density and enhance timber production. Other land cover classifications included in the forage area analyses were open vegetation (meadows, grasslands and muskegs), other non-forest (freshwater, brush, urban areas), and alpine (high elevation, sparse vegetation, rocks and snow). We resampled all GIS data to a 30 m^2 cell resolution.

We quantified the proportion of each land cover type within each individual wolf's denning season home range area using the Tabulate Area tool in ArcMap. We tested for differences in proportions of home range area land cover among 1) breeding wolves, 2) non-breeding wolves associated with an active den, and 3) wolves not associated with an active den using ANOVA with Tukey's post hoc tests ($\alpha = 0.05$).

Seasonal home ranges

We tested for differences in wolf pack home range size across seasons using an ANOVA with Tukey's post hoc tests ($\alpha = 0.05$). In addition to examining home ranges at the wolf-pack scale, we also investigated differences in individual seasonal wolf home ranges and movement models. We first calculated the position autocorrelation time, interpreted as the time required to cross the home range (Péron et al. 2017) for each wolf using ctmm (Calabrese et al. 2016, Fleming and Calabrese 2017). We then used generalized linear models (GLMs) with gamma distribution errors and a log link function to examine the relationship between individual wolf home range size and wolf characteristics (individual identity, wolf pack membership, sex, breeding status, association with an active den) and temporal characteristics (season and year). We separately examined the relationship between home range size during the pup-rearing season and wolf characteristics. We used Bayesian information criterion (BIC) to select the top-ranked model and ranked them according to their weights (BIC_W). Additionally, we evaluated the relationship between the best-fitting movement model for each individual wolf and wolf characteristics using multinomial logistic regression. Analyses were conducted using the lme4 (Bates and Sarkar 2006) and nnet (Venables and Ripley 2002) packages with R software.

Results

Captures and monitoring

During 2012–2016 we monitored 13 radiocollared wolves (eight females and five males) in seven packs with 1–5 wolves radiocollared in each pack. On average GPS collars recorded 809 locations (SD = 415) per wolf, over a time interval of 401 days $collar^{-1}$. We detected 11 active den sites on POW during the study period, six of which had radiocollared wolves associated with them. Using the GPS data, visual observations on the ground and photos of wolves from the motion-detecting cameras, we identified the breeding and non-breeding collared wolves at the active den sites. Of the 11 den sites we found, 6 (55%) had been previously used during 1995–2003 (Person and Russell 2009). Five dens had no previously recorded use by wolves. Two den sites were used for two consecutive years during our study period.

Home range estimation

Core and denning home range area

During our study period, the mean den entry date was 2 May (range 20 April–21 May) and the mean den exit date was 1 July (range 20 June–21 July). Breeding wolves had earlier start dates of den occupancy (range = 20 April– 28 April) than non-breeding wolves associated with an active den site (range = 9 May–21 May; Supplementary material Appendix 1 Table A1). On average wolves occupied den sites for 59 days (SD = 22.3, range = 35–82, n = 5).

Denning season core use areas ranged from 3 to 405 km^2 (mean = 107 km^2, SD = 121 km^2) for all wolves, and there was a statistically significant difference in mean core area sizes among categories of wolves ($F_{2,10} = 4.91$, $p = 0.033$). The post hoc Tukey test revealed that the mean core area size of breeding wolves (6 km^2, SD = 4 km^2) and wolves not associated with an active den (206 km^2, SD = 142 km^2) differed significantly ($p = 0.038$; Table 1). The minimum width of the six active den sites to the core use area edge ranged from 53 m to 1654 m, whereas the maximum width ranged from 1815 m to 14 687 m. The core use area width was narrower for breeding wolves at active den sites (mean minimum distance = 734 m, SD = 577; mean maximum distance = 2308 m, SD = 500) reflecting their smaller core use areas (Table 1). Active den sites on POW during our study period (n = 11) were on average 0.91 km from the nearest road (range = 0.17–3.83 km, SD = 1.07 km).

Home range areas during denning season varied in size from 44 to 1411 km^2 (mean = 376 km^2, SD = 418 km^2) for all wolves. Similar to the core use area patterns, breeding wolves had a smaller mean home range area (57 km^2, SD = 10 km^2) in comparison to non-breeding wolves at

Table 1. Wolf core denning area (km²) estimated with 50% autocorrelated kernel density estimators (AKDE) during denning season (15 April–15 June), the minimum and maximum core use area width (m) at active den sites, and number of wolves included in each category (n), Prince of Wales Island, Alaska, USA, 2012–2016.

	Core denning area (km²)			Core area width (m)			
	n	Mean	SD	Minimum	SD	Maximum	SD
All wolves	13	107	121				
Breeding	3	6	4	734	577	2,308	500
Active den non-breeding[a]	5	69	45	1,638	1,577	10,344	6,317
Not associated with an active den[b]	5	206	142				

[a]Core area width is based on non-breeding wolves at active den sites (n = 3).
[b]Core area based on home range size of wolves in a pack with no reproduction during denning season.

an active den site (252 km², SD = 161 km²) and wolves not associated with an active den site (691 km², SD = 527 km²) although the difference was not statistically significant ($F_{2,10}$= 3.61, p = 0.066; Table 2). The low-volume and high/medium-volume old-growth forest categories made up the largest proportion of land cover within wolf home range areas for all wolves (34 and 28%, respectively, Table 2). The proportion of both old-growth forest categories did not differ significantly among the home range areas of breeding and non-breeding wolves, and wolves associated and not associated with active den sites. The proportion of other land cover types did not differ among wolf groups either, with the exception of old clearcuts which occurred proportionally more in breeding than in non-breeding wolf home range areas during denning season ($F_{2,10}$ = 10.93, p = 0.003).

Seasonal home ranges

Seasonal home range size varied among packs, with AKDE-calculated home ranges varying from 115 to 922 km² among seasons (Table 3). Wolf pack home range sizes were not significantly different between seasons ($F_{3,21}$ = 0.25, p = 0.895). Home range size also varied among individuals (mean = 349 km², SD = 260 km², range = 41 km²–1411 km²). The semi-variance function that best fit the wolf location data (top-ranked model via AICc for 32 of 49 individual wolf seasonal home range models) was the anisotropic form of the Ornstein–Uhlenbeck foraging movement model, with anisotropic Ornstein–Uhlenbeck (n = 13) and isotropic Ornstein–Uhlenbeck foraging models (n = 4) comprising the remainder of top-ranked models. The average time for a wolf to cross the linear extent of its home range (autocorrelation time) was 2.89 days (SD = 2.37), and was less during fall (1.95 days, SD = 0.99) in comparison to the pup-rearing season (3.40 days, SD = 2.61), late summer (3.09 days, SD = 2.71), or late winter (3.32 days, SD = 2.91; Table 4).

Wolf pack membership was the most important variable explaining individual wolf home range sizes across all seasons (ΔBIC = 2.1 from next top-ranked model, BIC_W = 0.736; Supplementary material Appendix 2 Table A2), whereas pack membership, breeding status, and association with an active den site were the most important variables explaining individual wolf home range size during the pup-rearing season (ΔBIC = 2.54 from next top-ranked model, BIC_W = 0.78; Supplementary material Appendix 3 Table A3). At the individual wolf level, pup-rearing season home ranges were smaller for wolves associated with an active den site (β = –0.939, SE = 0.236, p = 0.016), and for breeding wolves (β = –0.798, SE = 0.236, p = 0.028; Supplementary material Appendix4 Table A4). Examination of individual home ranges of wolves during the pup-rearing season revealed breeding wolves had smaller home range sizes (mean = 165 km²) than non-breeding wolves (mean = 459 km²; t_{11} = –2.19, df = 10.9, p = 0.051).

Table 2. Mean and standard deviation ($\bar{x}$ [SD]) of wolf home range areas (km²) estimated across each category with 95% autocorrelated kernel density estimators (AKDE) during denning season (15 April–15 June), the number of wolves included in each category (n), and the mean and standard deviation ($\bar{x}$ [SD]) of the proportion of each land cover category in the home range areas, Prince of Wales Island, Alaska, USA, 2012–2016.

	All wolves	Breeding	Active den non-breeding	Not associated with an active den
n	13	3	5	5
Home range area (km²)	376 (418)	57 (17)	252 (161)	691 (527)
High/medium-volume old-growth forest	0.28 (0.068)	0.32 (0.010)	0.29 (0.084)	0.25 (0.066)
Low-volume old-growth forest	0.34 (0.069)	0.26 (0.046)	0.35 (0.068)	0.36 (0.054)
Young CC[a]	0.09 (0.049)	0.13 (0.012)	0.04 (0.023)	0.11 (0.015)
Old CC[b]	0.10 (0.076)	0.19 (0.012)	0.07 (0.068)	0.12 (0.069)
Thinned[c]	0.09 (0.045)	0.07 (0.030)	0.11 (0.046)	0.08 (0.051)
Open[d]	0.02 (0.013)	0.01 (0.023)	0.02 (0.011)	0.01 (0.009)
Other non-forest[e]	0.08 (0.088)	0.01 (0.006)	0.11 (0.123)	0.09 (0.053)
Alpine[f]	0.01 (0.014)	0.00 (0.000)	0.02 (0.021)	0.00 (0.005)

[a]≤30 years since clearcut.
[b]>30 years since clearcut.
[c]≥ 50% of forest stands were precommercially treated.
[d]meadows, grasslands and muskegs.
[e]freshwater, brush, urban areas.
[f]high elevation, sparse vegetation, rocks and snow.

Table 3. Monitoring period by pack and season (pup-rearing: 15 April–31 July, late summer: 1 August–14 October, fall: 15 October–31 December, and late winter: 1 January–14 April), and wolf pack home range size (km²) estimated with minimum convex polygons (MCP) and autocorrelated kernel density estimators (AKDE), Prince of Wales Island, Alaska, USA, 2012–2016.

Pack	Monitoring period	Home range size (km²)	
		MCP	AKDE
Pup-rearing			
Honker	2012–2014	516	922
Hydaburg	2013	168	211
Nossuk	2013	375	585
Ratz	2012	100	251
Sandy Beach	2015–2016	265	241
Staney	2012–2015	110	145
Trocadero	2016	116	217
Mean (SD)		236 (159)	394 (283)
Late summer			
Honker	2012–2014	363	356
Hydaburg	2013	180	220
Nossuk	2013	375	533
Ratz	2012	392	840
Sandy Beach	2015	195	292
Staney	2013–2014	131	157
Trocadero	–	–	–
Mean (SD)		273 (116)	400 (252)
Fall			
Honker	2012–2014	687	558
Hydaburg	2013	183	161
Nossuk	2013	465	545
Ratz	2012	450	249
Sandy Beach	2015	324	115
Staney	2012–2013	257	268
Trocadero	–	–	–
Mean (SD)		394 (180)	316 (191)
Late winter			
Honker	2012–2014	730	772
Hydaburg	–	–	–
Nossuk	2012	447	533
Ratz	2012	312	219
Sandy Beach	2014–2015	122	133
Staney	2012–2014	128	120
Trocadero	2016	565	917
Mean (SD)		384 (243)	449 (344)

The best-fitting movement model contained sex and breeding status as explanatory variables ($\Delta BIC = 6.62$ from next top-ranked model, $BIC_W = 0.963$). In comparison to the most common movement model (the anisotropic form of the OUF, for 32 of 49 individual wolf home range models), females were more likely to conform to the OU anisotropic model than males ($\beta = 2.140$, $SE = 1.128$, $p = 0.057$) and breeders were more likely to conform to the OU anisotropic model ($\beta = 2.303$, $SE = 1.189$, $p = 0.052$). Indeed, of the 13 individual wolf home range models conforming to this movement model, 12 were female home range models, and included all of the wolves that were documented as breeding. The isotropic OUF model represented all females of non-breeding status, whereas the anisotropic OUF consisted of both non-breeding males and females.

Table 4. Mean and standard deviation (SD) of seasonal (pup-rearing: 15 April–31 July, late summer: 1 August–14 October, fall: 15 October–31 December, and late winter: 1 January–14 April) individual wolf home ranges (km²) estimated with 95% autocorrelated kernel density estimators (AKDE), mean and SD of home range crossing times (days), and number of individual seasonal wolf home ranges (n), Prince of Wales Island, Alaska, USA, 2012–2016.

	n	Home range	SD	Home range crossing time	SD
Pup-rearing season	13	391	352	3.4	2.61
Late summer	12	337	207	3.09	2.71
Fall	14	270	169	1.95	0.99
Late winter	10	419	292	3.32	2.92

Discussion

Evaluation of core use area during denning season

The objectives of the revised den management recommendations included permanent protection of den sites, maintaining sufficient habitat and activity buffers around dens to buffer wolves from development and human activity, and retaining sufficient old-growth forest in foraging areas for pup-rearing. The area surrounding wolf dens required for protection has been proposed in other systems and varies depending on the magnitude and timing of the potential disturbance, the quality of the surrounding habitat matrix, and the legal status of the wolf population. For example, buffers of 1.6–10 km have been recommended to reduce disturbance surrounding den sites in British Columbia, the Canadian and US Rocky Mountains, and interior Alaska (Chapman 1977, Matteson 1992, Fritts et al. 1994, Paquet and Darimont 2002) and were determined from observations of wolf behavior and habitat characteristics of den sites. The current buffer recommendations in the Tongass National Forest Land and Resource Management Plan (366 m; USFS 1997, 2008, 2016) are considerably smaller and believed to be sufficient for wolves during denning season to prevent relocations of pups to another den site in response to noise from ground-based timber harvest activities and other disturbance in forested habitats due to noise attenuation (Wolf Technical Committee 2017). For louder activities such as helicopter overflights and road construction, a buffer of 805 m (0.5 mile) was recommended. The rationale used to establish the 366 m buffer distance was unspecified (D. Person pers. comm.) highlighting the importance of transparently defining justification for management criteria, and the specific information required to meet these criteria.

Our research quantified core use areas to inform management efforts to protect dens from disturbance by using empirical data to describe wolf space use and movement patterns. Although we did not specifically evaluate wolf tolerance of human disturbance, we believe that these data reflect habitat and space requirements around active den sites during the denning period when pups are most vulnerable. Based on our results, the current recommend buffer does not encompass denning use areas. Despite breeding wolves having smaller core use areas (and corresponding den buffer widths), the mean distance of the edge of their core home range from the active den still exceeded the current recommended forest buffer distance (366 m) around the den site by nearly 2 (734 m) to more than 6 times (2308 m). When considering the non-breeding pack members associated with an active den site, the mean core home range edge further exceeded the buffer distance recommended for both

ground-based disturbance (by a minimum of 1272 m) and louder noises (by a minimum of 833 m).

Protection of breeding wolves during the early denning season is an essential step to ensure reproductive success and population viability; however, because wolves are cooperative breeders it is also important to consider the requirements of the non-breeding members of the wolf pack. These wolves play an important role in both attending and provisioning the pups especially before weaning due to reduced mobility of the breeding female (Ballard et al. 1991, Potvin et al. 2004, Ruprecht et al. 2012). Conversely, because they are not as closely tied to the den site, these wolves may be better able to cope with disturbance. Inspection of individual wolf home ranges in our study revealed much variation in home range size, with breeding status emerging as the major influencing factor. As has been documented in other wolf populations, reproductive status influences space use as breeding wolves travel shorter distances, are less active, and have higher den attendance rates than non-breeding wolves (Theuerkauf et al. 2003, Potvin et al. 2004) translating to smaller home ranges for the breeding pair than non-breeding pack members (Hinton and Chamberlain 2010). These results underscore the importance of evaluating space use in terms of individual characteristics, as individual variation can be obscured when evaluating home range size at the pack level.

Home range area and habitat during denning season

The extent of home range areas was also variable during denning season and mainly influenced by breeding status, with smaller home range areas for breeding than non-breeding wolves. As breeding status influenced individual variation in core and home range sizes during denning season, movement patterns also varied according to this factor. Breeding females conformed to the OU anisotropic movement model indicating that they displayed discontinuous velocity and tortuous movements relative to other wolves, particularly during the pup-rearing season and late summer. Breeding females have high attendance rates at dens especially post-parturition (Ballard et al. 1991, Potvin et al. 2004, Ruprecht et al. 2012), and maintaining close proximity to den sites could provide an explanation for convoluted movement patterns resulting in irregular speed. In contrast, the majority of the non-breeding wolves (which have variable attendance rates at den sites) in our study, displayed foraging movement patterns (OUF) indicating continuous velocity and directional movement. Space used shifted during fall as all wolves (regardless of breeding status) took less time to cross their fall home ranges than during other times of the year, coinciding with the period when pups become more mobile and movements patterns radiating from a den or rendezvous site are no longer necessary.

The quantity of each land cover category in the home range areas during denning season was mostly proportional to the land cover quantities within the greater study area (north-central POW, Fig. 1), with old-growth forest making up the majority of the home range areas, and other non-forest, clearcuts, treated forest, and open vegetation occurring in declining quantities (Table 1, Roffler et al. 2018). Therefore, the habitat quality within home range areas during denning season reflected the existing habitat at the landscape scale. There was little variation in the proportions of land cover categories based on breeding-status or association with an active den site indicating that breeding status was more influential to the overall quantity of area used by an individual rather than the quality of the habitat. One notable exception was a higher proportion of old clearcut forest in the home range areas of breeding wolves during denning season. Previous habitat selection research demonstrates that wolves avoid old and young clearcuts during denning season despite proximity and inclusion within the home range (Person and Russell 2009, Roffler et al. 2018). During this study den sites were generally located in old-growth forest, corroborating previous results (Person and Russell 2009), but examination of the surrounding landscape revealed the occurrence of old clearcut forests sometimes in close proximity to den sites (0.1–1 km). This pattern of den site selection reflected hierarchical habitat selection demonstrated in some wolf populations wherein wolves select a territory and within it the most favorable habitat for den sites to reduce risk (Trapp et al. 2008, Sazatornil et al. 2016).

Differences in the proportion of old clearcut forest in denning home ranges may be explained by variation in movement patterns. Breeding wolves, due to their restricted mobility may be unable to use more old growth forested habitat because it would necessitate greater travel distances from the den site. In contrast non-breeding wolves had home ranges areas approximately 8 times larger than breeding wolves and therefore a greater ability to incorporate more old-growth forest into their home ranges despite the proximity of unfavorable habitat (i.e. clearcuts). Of note is that clearcuts were avoided within denning season home ranges during 1995–2004 (Person and Russell 2009) and during 2012–2016 (Roffler et al. 2018), all the while becoming a more common land cover category.

During our study period over half of the den sites (n = 6) had been used previously during 1995–2003. The consistent reuse of these historic den sites by wolves could be due to variety of factors including learned behavior, or a limitation in availability of favorable denning habitat. However, the ability of wolves to establish new den sites (n = 5) was also documented during this study indicating some degree of flexibility in den site selection, sufficient availability of den habitat, or both. Due to demonstrated use of historic den sites with recorded denning activity up to 17 years previously, and reuse of den sites during this and earlier research (Person and Russell 2009), the Interagency Wolf Habitat Management Program recommended changes to the Forest Plan to indefinitely protect known den sites (instead of only for active dens) are supported.

Seasonal home range and movement patterns

Overall, there was a great deal of variability in wolf seasonal home range size and space use throughout the year, with differences explained more by wolf pack membership than by seasons. Home range sizes are negatively related to habitat quality (Kittle et al. 2015), prey density (Fuller 1989, Mattisson et al. 2013, Lake et al. 2015), and wolf density (Peterson et al. 1984, Ballard et al. 1987), and can also be influenced by pack composition (Tallents et al. 2012), ter-

rain features, and harvest (Rich et al. 2012). One pack in our study (the Honker pack) had larger pup-rearing home ranges than those of other packs (Table 3). There was evidence of multiple breeding females in the Honker pack during late May–mid July 2014, as radiocollared wolves, unmarked adults and pups were observed at two den sites 8 km apart. Occurrence of multiple breeding females in wolf packs is not common (6–8% of all packs; Mech 2000, 15.8% of all packs Ausband 2018), but could have contributed to the larger pup-rearing home range size of this pack (Table 3). Turnover of the breeding female is associated with the occurrence of multiple breeding females in a pack (Ausband et al. 2017). Additionally, the Ratz pack budded from the Honker wolves in 2012 and occupied an adjacent territory for 10 months but made occasional forays after the pup-rearing season into the Honker home range. This pattern is consistent with budding events documented elsewhere with overlap of the new and the originating pack home ranges, although overlap is lowest during the early denning season (Jędrzejewski et al. 2004). The budding event also contributed to the partly larger late summer and fall home range sizes of the Honker and Ratz packs relative to other packs in the study area (Table 3).

Seasonal pack home range sizes did not vary as much throughout the year as previously reported (Person 2001). Similar home range sizes between the pup-rearing period and late winter have been more commonly documented (Potvin et al. 1988, Fuller 1989) and are attributed in part to lower pack cohesion (Metz et al. 2011) and rotational foraging patterns (Demma and Mech 2009) during summer. Seasonal pack home range sizes were also larger than those previously reported (Person 2001), which were calculated using both MCPs and kernel density estimators (KDEs). This could be due to either methodological or ecological factors. Our study used GPS radiocollars, whereas Person (2001) used VHF radiocollar data collected at longer time intervals (every 5–14 days) to determine home range size. Rarefication of our location data to assess the effects of less frequent position fixes on home range size resulted in MCP home ranges that were ~30% smaller and KDE home ranges that were 10–25% larger than our position fix rate (ADF&G unpubl.). However, we also used a method to account for spatial autocorrelation; therefore, due to the underestimation of home range size from standard methods (such as KDEs; Fleming et al. 2015), we would expect the AKDEs to be larger. Because home range sizes have an inverse relationship with habitat quality, prey biomass, and wolf density (Ballard et al. 1987, Fuller et al. 2003, Kittle et al. 2015), the larger home range sizes we reported could also be due to ecological factors, including a decrease in wolf density on POW over the past two decades (Person et al. 1996, Roffler et al. 2016), or ecological changes affecting prey density such as reductions of high-quality winter deer habitat (i.e. low elevation old-growth forests).

Management implications

The intent of the Wolf Technical Committee is to provide recommendations to maintain the integrity, attractiveness, and productivity of den sites with forested buffers which will be perpetually protected. The median value of the minimum and maximum distance between the core home range edge and a den site was 3756 m for all wolves associated with an active den. Therefore, land managers working to protect den sites should consider expanding the much smaller guideline den site buffers in place now to this larger size. The shape of the protected polygon surrounding the den should be selected to maximize high quality denning habitat (flat, low elevation terrain, in old-growth forests, near freshwater and distant from high density road areas, Person and Russell 2009, Roffler et al. 2018). Therefore, the buffer width may vary to accommodate high-priority habitat but should not be less than 734 m (the minimum buffer width for breeding wolves). To maintain foraging habitat for wolves during denning season, it is recommended the proportion of old-growth forest should not be reduced below the current values (61% of the core home range area for wolves associated with an active den). The timing of the restrictions to activities that could cause disturbance is a key consideration; restrictions could be loosened as pups become more mobile (> 6 weeks old) and able to respond to disturbances (Frame et al. 2007). The recommended period for seasonal management activity restrictions around active dens is 15 March–15 July based on earlier work by Person and Russell (2009; Wolf Technical Committee 2017); however, wolves were documented during this study at dens as late as 21 July, and the mean den occupancy was nearly two months, thus extending the restriction period to late July would be a conservative management action. Because wolves display a flexible response to road density throughout the year by avoiding areas with high road densities during denning season, but selecting these areas during winter (Roffler et al. 2018), timing is also a consideration in road closures as a management action. Considering the pattern of repeated historical den site and habitat use, measures to maintain old-growth habitats surrounding documented den sites will help maintain the potential for successful wolf reproduction.

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Supplementary material (available online as Appendix wlb-00468 at <www.wildlifebiology.org/appendix/wlb-00468>). Appendix 1–4.

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Riparian Windthrow – Northern Vancouver Island

Terry Rollerson3
Kerry McGourlick4

Abstract

Windthrow in riparian reserves and riparian management zones along streams on Northern Vancouver Island is chronic. It can range in degree, from isolated individual trees or small groups of trees to occasional areas where all the trees are windthrown. This study documents the amount and distribution of windthrow and evaluates relationships among various environmental and management factors, and windthrow. The factors most strongly associated with windthrow in riparian forests are: the type of treatment applied to the boundary, the character of the leave strip (one-sided versus two-sided strips), strip width, rooting depth, exposure of the boundary to wind, tree height and tree species. To a lesser degree, soil drainage, landform morphology, and the position of the boundary on the slope relative to certain morphologic features of landforms are also important.

Introduction

The implementation of the BC Forest Practices Code (FPC) has resulted in a significant increase in the number and type of riparian reserves and forested riparian management zones being established along streams on Northern Vancouver Island. This increase in the frequency of forested riparian buffers is leading to increasing concern over the amount of windthrow that occurs, and the possible effects of this windthrow on stream channels and other ecological values within these riparian areas. These concerns are coupled with a desire to predict where windthrow is most likely to occur and to develop methods to control riparian windthrow or mitigate its effects.

This study was set up to document the amount and distribution of riparian windthrow, and to evaluate relationships among various environmental and management factors and the frequency of windthrow. The focus of the study is on riparian management areas set up within the Northern Vancouver Island operations of Western Forest Products Ltd. At the time field sampling for this study was conducted, riparian reserves and management zones established to FPC standards had experienced one or two winter storm seasons. Streamside management zones established under the guidance of the BC Coastal

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3 Senior Geoscientist, Golder Associates Ltd. RR#2 Site 55 C58 1462 Broadview Road Gabriola, B.C. V0R 1X0. Telephone: (250) 247-9802. E-mail: trollerson@golder.com

4 Regional Forester, Western Forest Products Ltd. Mainland/Islands Region. 118-1334 Island Highway, Campbell River, B.C. V9W 8C9. Telephone (250) 286-4123. E-mail: kmcgourlick@westernforest.com

Fish/Forestry Guidelines (CFFG) that are comparable to the riparian management areas as defined by the FPC were also sampled. Most of these streamside management zones had experienced several winter storm seasons.

Objectives

The study objectives included:

- Evaluation of the extent of riparian windthrow in logged areas on Northern Vancouver Island that were harvested to FPC and/or CFFG standards.
- Evaluation of factors associated with riparian windthrow.
- A qualitative evaluation of the short-term effects of riparian windthrow on streams.
- Development of a rapid, relatively low-cost, field methodology suitable for the assessment and monitoring of post-harvest windthrow conditions.

Study Area

The study includes the Port McNeill, Holberg and Jeune Landing operating areas of Western Forest Products Ltd.

The Port McNeill and Holberg operating areas are located within the Nahwitti Lowland subdivision of the Hecate Depression on Northern Vancouver Island. The Nahwitti Lowland encompasses the northern end of Vancouver Island north of a line drawn between Englewood and Quatsino Sound. It is an area of low rounded hills and ridges within the Hecate Depression. Elevations rarely exceed 600 meters above sea level (a.s.l.) except for a few isolated summits (Holland, 1976).

The Jeune Landing operating area lies within the northern portion of the Vancouver Island Mountains, a major northwest to southeast-trending physiographic unit that forms the core of Vancouver Island (Holland 1964). Elevations range from sea level to 2200 meters. This portion of the Vancouver Island Mountains can be subdivided into two sub-units consisting of the North Vancouver Island Ranges and the Vancouver Island Fiordland (Hoadley 1953; Yorath and Nasmith 1995). The North Vancouver Island Ranges tend to be more rugged and have greater relief than Fiordland.

Most of the study area lies within the Submontane Very Wet Maritime variant (CWHvm1) of the Coastal Western Hemlock (CWH) biogeoclimatic zone and the Southern Very Wet Hypermaritime variant (CWHvh1) of the CWH biogeoclimatic zone. Western hemlock, balsam and cedar dominate the forest cover within the area. There are large areas of second growth plantations within the study area.

Climate

Northern Vancouver Island is characterized by cool, wet winters and moist, warm summers. Snow is usually confined to higher elevations but is often present for short periods at lower and mid elevations and the area is subject to occasional

rain-on-snow events. High intensity/long duration storms, often accompanied by strong winds, occur during the fall and winter months. The highest monthly precipitation averages occur between October and January. Snow generally occurs between November and March.

Methods

The initial phase of the project included a helicopter reconnaissance of a number of riparian reserve and riparian management zones in Western Forest Product's operating areas on Northern Vancouver Island. We then reviewed past logging plan maps to identify candidate harvest units and riparian areas that were logged to FPC or CFFG standards and had experienced one to several winter storm seasons. This compilation involved WFP's Port McNeill, Holberg and Jeune Landing Operations. The Port McNeill and Holberg operating areas are located within the Nahwitti Lowland while the Jeune Landing operation is confined to the northern portion of the Vancouver Island Mountains.

Between 60 and 65 logged blocks contained forested riparian areas that appeared to meet the selection criteria, of these, 58 blocks proved suitable for study and were sampled during the course of the project. The field phase of the study involved ground traverses of all forested riparian areas within each block selected for sampling.

All riparian reserve zones and forested riparian management zones5 in FPC blocks and streamside management zones in CFFG blocks on S1 to S6 streams were sampled if they had experienced at least one winter season. Each riparian strip was stratified into distinct geomorphic and/or geometric 'entities'. This stratification resulted in the creation of unequal length plots or 'sample segments'. The sample stratification or separation was based on the following field criteria:

- The type of forested riparian area. Riparian areas were classified as 1-sided leave areas or 2-sided leave areas (i.e., external stand edges versus strips of timber bounded by clearcut areas on either side).
- Significant changes in the orientation (aspect) of the riparian boundary.
- Change in classification of the stream contained within the riparian area.
- Visible and significant changes in slope, terrain and/or soils along the boundary.
- Changes in forest type along the boundary.
- Type of riparian treatment: untreated, feathered, thinned.
- The sample segments (plots) had to be a minimum of 50 meters long. Shorter segments were discarded.
- Two-sided riparian strips were sampled on both sides, each side of the strip was treated as a separate sample.

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5 The term 'forested riparian management zone' is used to distinguish between "forested" riparian management zones where trees are retained and riparian management zones where all or almost all trees are cut. Riparian areas where small conifer regeneration (i.e. generally less than 2-3 meters tall) was retained were not sampled.

- Changes in the amount or character of windthrow did not affect sample selection.

We used stratified, unequal length sample segments (plots) to improve sampling efficiency and to ensure that any visible environmental differences that could potentially exert a significant effect on windthrow response were sampled. For example, random or systematically located plots that fell across significant changes in soil type or boundary orientation could well confound any subsequent analysis if these factors strongly affect windthrow susceptibility. Because the two important target variables (percent windthrow and distance of penetration of windthrow) should not be affected by sample segment length we did not feel that differences in the length of the plots would significantly affect the outcome of the study. Additionally, some terrain types are inherently quite variable over relatively short distances so sampling the full length of such 'strata' should generate a more representative estimate of the amount windthrow occurring within these more heterogeneous terrain types. For the objective of estimating cumulative windthrow along riparian boundaries, unequal length sampling segments work very well. All segments along all riparian strips traversed were sampled, except for a few short (<50 meter) segments that were discarded. We selected a minimum sample segment distance of 50 meters because we were interested in making a qualitative assessment of the spatial patterns of windthrow present in the area and felt that shorter sampling segments would likely obscure any spatial pattern that might exist.

Much of the data collected in the field was restricted to visual classification of such items as soil type, slope morphology, surficial materials, boundary geometry, and stream class. In order to streamline data collection we did not collect data on the actual number of trees windthrown or standing. Instead, we made visual estimates of the amount of windthrow present based on nominal classes of: 0, 1, 2, 5 and then increasing increments of 5 or 10%. Similarly, we visually estimated the 'average' primary and secondary orientations of windthrown trees in a sample strip rather than the orientation of each individual tree. We developed a qualitative wind exposure index, or ranking matrix (Figure 1), to represent the vulnerability of boundaries that are subject to winds from more than one direction. Forest types and heights were estimated visually and then compared to forest cover information included on the logging plan map for the block. We also recorded any stand edge treatments that had occurred along each sample segment. In total 447 riparian segments were sampled representing about 76 kilometers of falling boundary.

We carried out simple graphical analysis of the data to identify obvious trends and patterns in the data that might be associated with changes in riparian windthrow. Two non-parametric tests, the Mann-Whitney, and the Kruskal Wallis, were used to test for significant differences in amount of windthrow between or among variable categories. We also carried out a limited amount of segmentation analysis using CHAID (Chi-squared automatic interaction detector – SPSS, 1998) to develop a prototype windthrow hazard classification (decision tree) for Northern

Vancouver Island. The use of segmentation analysis to develop windthrow hazard models was pioneered by Kennedy (1974), for studies of windthrow in Northern Ireland.

Results and Discussion

Riparian windthrow within the study area averaged about 21% of the standing timber along stream edges. There are a large number of plots with only a minor amount of windthrow and conversely only a limited number of areas with substantial amounts of windthrow (Figure 2). The average distance of penetration of windthrow into the standing timber was about 12 meters.

Two-sided riparian strips are in general much more vulnerable to windthrow than one-sided riparian strips (Tables 1 and 2). Two-sided strips experience about twice the amount of windthrow as one-sided strips. The distance windthrow penetrates in to the residual stand is also higher for two-sided riparian strips.

The type of edge or strip treatment has a significant effect on the amount of windthrow. Strips with feathered edges tend to experience the least amount of windthrow (7%), followed by untreated strips (18%). The lower amounts of windthrow along feathered edges is most likely due to the successful identification and removal of the more vulnerable trees along these edges. There may be a secondary compensating effect in that removal of these trees means that they cannot knock other trees over in the process of blowing over themselves (i.e., the 'domino effect' is constrained). Uniformly thinned strips and strips where only the smaller merchantable trees have been retained experience substantially higher percentages of windthrow among the retained trees (Table 1 and Figure 3). The distance windthrow penetrates into riparian areas does not appear to vary significantly between feathered and untreated edges but appears significantly greater in thinned areas where only smaller trees have been retained.

Except for rooting depth, where there is a tendency for more windthrow to occur as rooting depth increases, comparisons of between various environmental variables and the amount of windthrow in thinned, two-sided leave strips show no significant differences. These treatments are not discussed further. Rather we focus on the apparent relationships between various environmental variables and windthrow along untreated or feathered riparian strips.

There are a large number of variables that are associated with windthrow along untreated and feathered riparian edges. A number of these factors co-vary so although most will be discussed below, not all need to be taken into account when evaluating the potential for windthrow along a riparian boundary.

The width of riparian strips appears to play a significant role, with wider strips having less windthrow (Figures 4 and 5). The effect appears to be more pronounced for two-sided compared to one-sided strips. For one-sided strips, the effect of increasing width appears to diminish once the strip is 25 to 30 meters wide. However, for two sided strips, windthrow frequencies appear to continue to

decrease up to a width of about 40 meters (these distances represent the strip width on one side of the stream only).

The location of a boundary relative to morphologic features on a hillslope can have an effect on the amount of windthrow experienced (Table 2). Falling boundaries located along the edge of steep stream escarpments and gully sides appear to experience substantively more windthrow than boundaries at other slope locations. Boundaries that are set back 10 to 20 meters from the edges of these features appear to experience much less windthrow (these setback boundary locations are classified as 'hillslope-escarpment' and 'hillslope-gully' in Table 2). Downhill boundaries on slopes of 10 to 60% and boundaries on level or very gentle slopes may experience slightly lower rates of windthrow than lateral boundaries. Lateral boundaries, which run up or down hillslopes, typically lie perpendicular or diagonal to the long-axis of a valley and so may be more vulnerable to up and/or down-valley winds.

The presence of shallow soils and shallow rooting as well as asymmetrical root, stem and crown development in the trees growing along gully and escarpment slopes may be the reason they are more vulnerable to windthrow. Typically, the crowns of the trees along gully sides and stream escarpments are more extensive (heavier) on the downhill (stream) side of the tree and some trees on these steep slopes lean out into the gully or over the stream. Shallow rooting and the asymmetrical form of these trees may make them more vulnerable to wind than trees located some distance back from the gully or escarpment edge. It is possible to feather the edges of setback boundaries but it is very difficult to feather a stand edge on a gully sidewall or steep stream escarpment unless trees are felled to waste. Consequently, some of the lower windthrow rates seen along setback boundaries compared to gully and escarpment edges may be due to the presence of feathering treatments.

The exposure or orientation of a boundary segment to storm winds is a significant factor. Boundary exposure (i.e., lee through windward) is defined as the relative orientation of the boundary to the apparent direction of winds in a block determined from the orientation of windthrown trees along the boundaries within the block. We define primary and secondary boundary wind exposure based on the apparent dominance (primary and secondary) of windthrow orientations around a block. Table 2 lists the windthrow amounts for the primary boundary exposure (boundary exposure 1). As boundary exposure ranges from lee through parallel to windward we assume that greater wind forces are applied to the trees along the boundary. As shown in Table 2 and Figure 6 there is an increasing amount of windthrow as well as increasing depth of windthrow penetration from lee through windward boundary exposure classes.

A similar, but perhaps more sensitive measure of apparent wind force is what we call the 'wind exposure index' (see Figure 1, for the derivation of this index). This index attempts to rank the cumulative effect of the primary and secondary winds for each specific segment (sample) along a riparian boundary. Reference to Table 2 and Figure 7 shows a strong relationship between the amount of windthrow and the wind exposure index. This index should be useful at the field

level for identifying boundaries that are potentially vulnerable to windthrow, either through the use of likely wind orientation determined from natural windthrow within a proposed block and/or by the documentation of post-harvest windthrow orientations in nearby areas.

A weak but still important relationship occurs between the valley axis orientation and windthrow. Riparian boundaries located in NE-SW and NW-SE trending valleys are more prone to windthrow than boundaries located in E-W and N-S trending valleys (Table 2). This finding suggests that some valley orientations favour the confinement of regional storm winds whereas other valley orientations may tend to disperse or disrupt these winds. This relationship may prove be more important in areas of high relief where valleys are well defined, than in areas of low relief where the valleys are not well defined.

There are several relationships that associate windthrow with the character of the riparian forests themselves (Table 2 and Figures 9). The strongest relationship is with the height class of the stands forming the riparian strips. There is a general increase in windthrow up to height class 4 and then a slight decrease or plateau in windthrow frequency with increases in height class. Because of small sample sizes, the apparent relationship between windthrow and taller height classes should be interpreted with caution.

A companion relationship is seen with age class as derived from forest cover maps. Windthrow is greatest for age class 4 and then decreases slightly to age class 8 (age classes 5 and 6 were combined because of the small number of cases in these categories). Age class 4 corresponds to a moderate number of ±90 year old, relatively tall, dense, uniform hemlock stands that regenerated after a severe windthrow event(s) in the early part of the century (these stands are known locally as the '1908 blowndown', but may include stands of earlier and later origin).

There is also an apparent relationship with the dominant tree species present in the various riparian strips. Stands dominated by hemlock appear to be more vulnerable to windthrow than either cedar or balsam fir. The sample for balsam dominated stands is quite small so the values for balsam should be interpreted with caution. Similarly, the '1908' stands are dominantly hemlock so this factor may bias the 'species' results somewhat. The hemlock trees in the '1908' stands tend to have a high height to diameter ratio that will tend to predispose them to windthrow.

No significant relationship was present for stand density class although there does appears to be a slight increase in windthrow as stand density increases. Again, there is likely some correspondence between this factor and the relatively young '1908' stands as they are typically quite dense.

There is no significant difference present between windthrow rates and surficial material types (Table 2). There are weak indications that morainal landforms may be slightly more prone to windthrow. Many of the areas dominated by morainal deposits are well to imperfectly-drained, with relatively deep rooting and moderately tall trees.

There is a moderately significant relationship between windthrow and soil drainage class areas (Table 2). Well to imperfectly drained sites (e.g., complexes of podzols and gleyed podsols) have the highest windthrow values followed closely by more uniform, well drained sites. Imperfectly to poorly and poorly drained sites (e.g., humic gleysols and/or humisols) have lower amounts of windthrow.

There is a strong trend of increasing windthrow with increasing rooting depth (Table 2, Figure 8). This result is contrary to most reported relationship between rooting depth and windthrow. On Northern Vancouver Island, we think that this result may be related to a correspondence between rooting depth and tree height. As rooting depth increases, tree height tends to increase, but there is also a general increase in the amount windthrow. It may be that the overturning forces generated by very strong winds at the base of taller trees growing on sites where there is relatively deep rooting simply overwhelm the resisting forces of the soil-root system.

Analysis of the data set for untreated and feathered riparian strips using CHAID points to a number of environmental and management-related factors associated with windthrow (Figure 10) and that can be used to generate windthrow hazard ratings. The general trend in the analysis is that rooting depth is the most useful variable for predicting the expected windthrow along a specific riparian boundary, with windthrow increasing as rooting depth increases. The next most useful variables depending on the particular branch of the CHAID tree that is being partitioned include the edge treatment (feathered or untreated) and the width class of the riparian strip. Once these variables have been stepped off, the model chooses wind exposure index to further partition the data and then finally height class. Similar decision trees can be generated to estimate the distance windthrow is likely to penetrate into a stand edge. The current analysis indicates that the multi-variate decision tree approach first pioneered by Kennedy in 1974 has significant promise as a practical tool for estimating windthrow hazard along setting boundaries.

Summary

The factors most strongly associated with windthrow in riparian forests are: the type of treatment applied to the boundary, the character of the leave strip (one-sided versus two-sided strips), riparian strip width, rooting depth, exposure of the boundary to wind, tree height and tree species. To a lesser degree, soil drainage, landform morphology, and the position of the boundary on the slope relative to certain morphologic features of landforms are also important.

Windthrow tends to in increase with increases in rooting depth, wind exposure and tree height. Narrow leave strips and 2-sided riparian strips are more prone to windthrow, especially when thinned. Stands dominated by cedar tend to be more windfirm than stands dominated by hemlock. Feathered edges tend to experience less windthrow than untreated edges. Slope morphology, and the position of the boundary relative to certain morphologic features of hillslopes can be important.

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Table 1. Management factors affecting windthrow (mean values) - all cases

Factor	N	% windthrow	Sig. levels	Penetration (m)	Sig. levels
Leave type:			**0.000**		**0.000**
One-sided	229	14		11	
Two-sided	218	28		14	
Treatment			**0.000**		**0.000**
Feathered edge	58	7		10	
None	283	18		12	
Uniform thinning	18	34		11	
Thinned small trees retained	88	35		14	

Note: all thinned strips are two-sided riparian areas but not all two-sided strips are thinned.

Table 2. Factors affecting windthrow – untreated and feathered edges

Factor	N	% windthrow	Sig. levels	Penetration (m)	Sig. levels
Leave type			**0.032**		**0.008**
One-sided	229	14		11	
Two-sided	112	21		14	
Boundary geometry			**0.099**		**0.138**
Escarpment edge	9	23		15	
Gully edge	29	29		14	
Hillslope-escarpment	25	17		13	
Hillslope-gully	57	13		13	
Downhill	44	13		12	
Flat to gentle	64	10		8	
Lateral	113	19		13	
Boundary exposure 1			**0.000**		**0.000**
Lee	18	5		9	
Lee diagonal	48	9		9	
Parallel	73	12		11	
Windward diagonal	121	21		13	
Windward	81	20		14	
Wind exposure index			**0.000**		**0.000**
1	1	1		40	
2	3	0.3		5	
3	22	8		9	
4	18	6		8	
5	47	9		8	
6	61	13		10	
7	66	18		13	
8	69	21		13	
9	54	27		17	
Valley axis			**0.041**		**0.063**
E-W	36	10		12	
N-S	182	14		11	
NE-SW	44	24		14	
NW-SE	79	21		13	

Table 2 Factors affecting windthrow – untreated and feathered edges cont'd

Factor	N	% windthrow	Sig. levels	Penetration (m)	Sig. levels
Dominant tree species			**0.044**		**0.153**
B	19	11		10	
C	125	10		11	
H	197	21		13	
Age class			**0.043**		**0.286**
4	19	23		19	
5.5	10	18		10	
8	292	16		12	
Height class			**0.015**		**0.117**
2	10	6		9	
3	32	10		8	
4	117	20		15	
5	118	15		11	
6	41	15		12	
7	3	1		12	
Stand density class			**0.165**		**0.441**
1	26	22		15	
2	286	16		11	
3	9	9		10	
Surficial material groups			**0.189**		**0.166**
Fluvial	12	7		7	
Fluvial and morainal	27	14		14	
Morainal	275	18		12	
Morainal and organic	9	5		6	
Organic	16	10		9	
Rock and morainal	2	15		10	
Soil drainage class			**0.022**		**0.071**
1 (well drained)	256	16		12	
2 (well to imperfectly)	52	24		13	
3 (imperfectly to poorly)	16	4		7	
4 (poorly)	17	9		8	
Rooting depth category			**0.000**		**0.103**
0.3 m	22	11		12	
0.4 m	72	9		10	
0.5 m	105	12		13	
0.6 m	70	24		14	
0.7 m	25	24		15	
0.8 m	15	38		17	
0.9 m	2	75		15	
1.0+ m	5	70		14	

Note: all values are mean values

Figure 1 Wind Exposure Index

		Boundary exposure 2	Lee	Lee diagonal	Parallel	Windward diagonal	Windward
			1	2	3	4	5
Boundary exposure 1							
Lee	1			**3**	**4**	**5**	**6**
Lee diagonal	2		**3**	**4**	**5**	**6**	**7**
Parallel	3		**4**	**5**	**6**	**7**	**8**
Windward diagonal	4		**5**	**6**	**7**	**8**	**9**
Windward	5		**6**	**7**	**8**	**9**	

Note: Wind Exposure Index = (Boundary exposure 1 rank) + (Boundary exposure 2 rank)

Wind Exposure Index rank:
3= very low
4 = low
5-7 = moderate
8 = high
9 = very high

The wind exposure index (WEI) is a simple, qualitative scoring scheme, developed for the riparian windthrow study, that ranks the expectation that a specific falling boundary segment will be affected by strong winds from more than one direction. The primary and secondary (or co-dominant) windthrow orientations for a block are compared in turn to each specific boundary segment orientation (aspect) to determine the primary and secondary exposure categories for that boundary segment (i.e., lee, windward or an intermediate exposure category). The assumption is made that the post-logging windthrow orientations in a sample block or boundaries in the immediate vicinity indicate the dominant wind directions that may affect a specific boundary segment. A simple ranking matrix is then created that lists boundary exposure categories along the x and y axes, defined as lee through windward and ranks them consecutively (i.e., lee = 1, parallel = 3, windward = 5). The individual rank values are added vertically and horizontally to determine the WEI for specific boundary segments or riparian sample strips. When there is only one windthrow (wind) orientation the WEI can be less than 3.

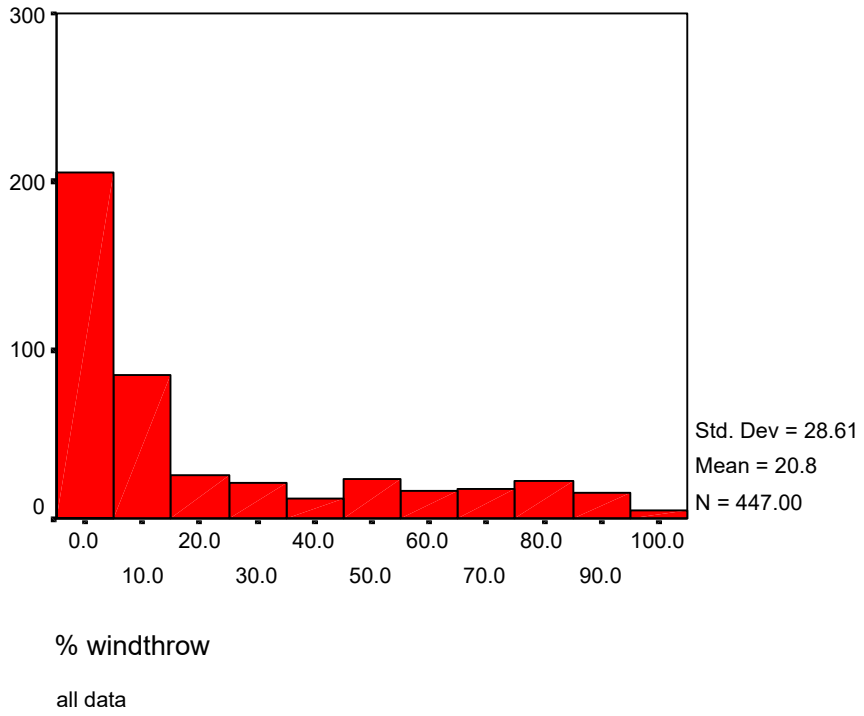


Figure 2 Windthrow distribution along all riparian edges (y-axis = number of samples)

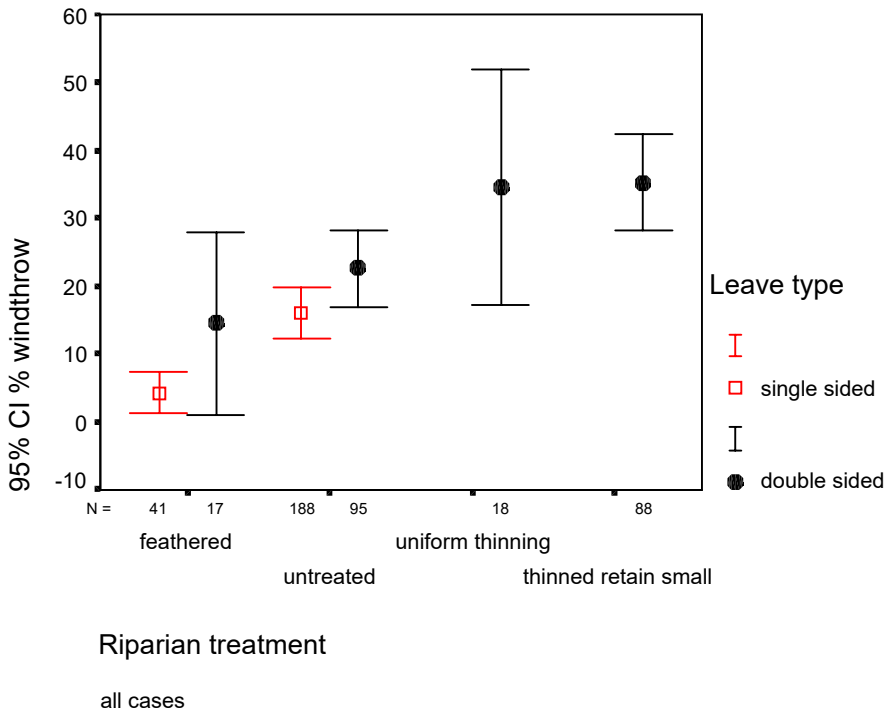


Figure 3 Windthrow distribution by leave type and treatment

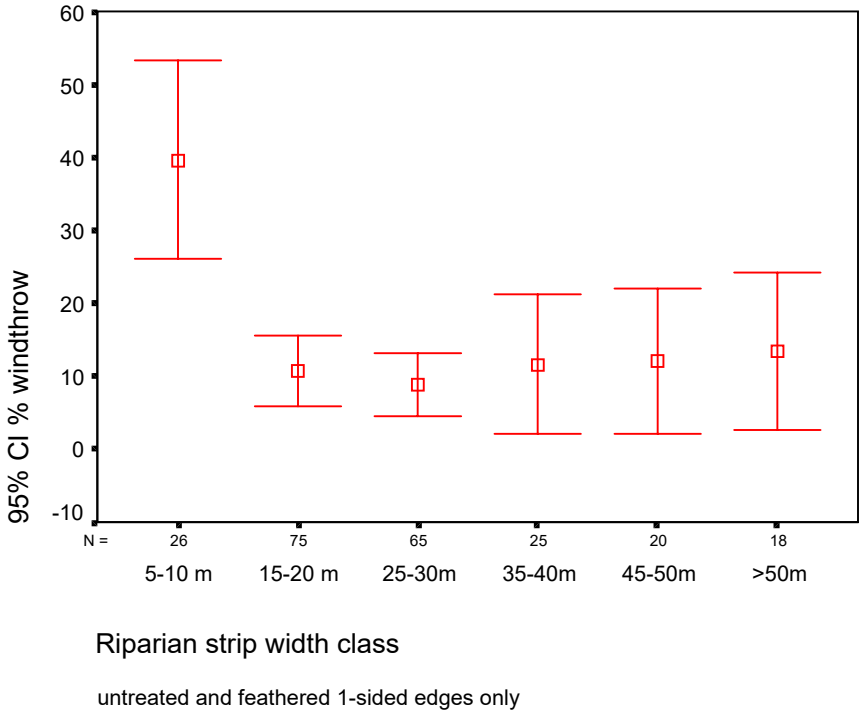


Figure 4 Windthrow versus width class for 1-sided strips

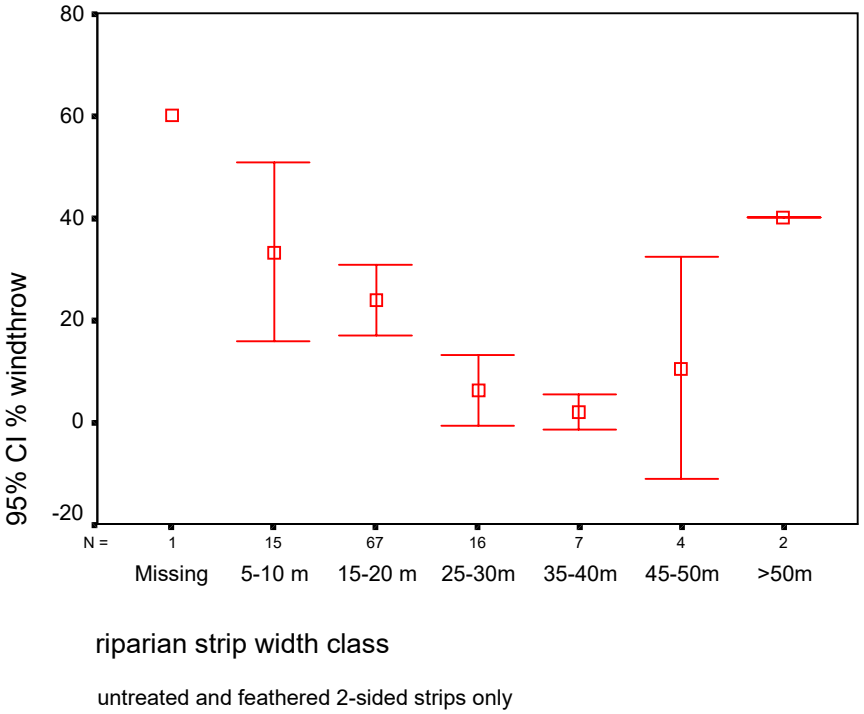


Figure 5 Windthrow versus width class for 2- sided strips

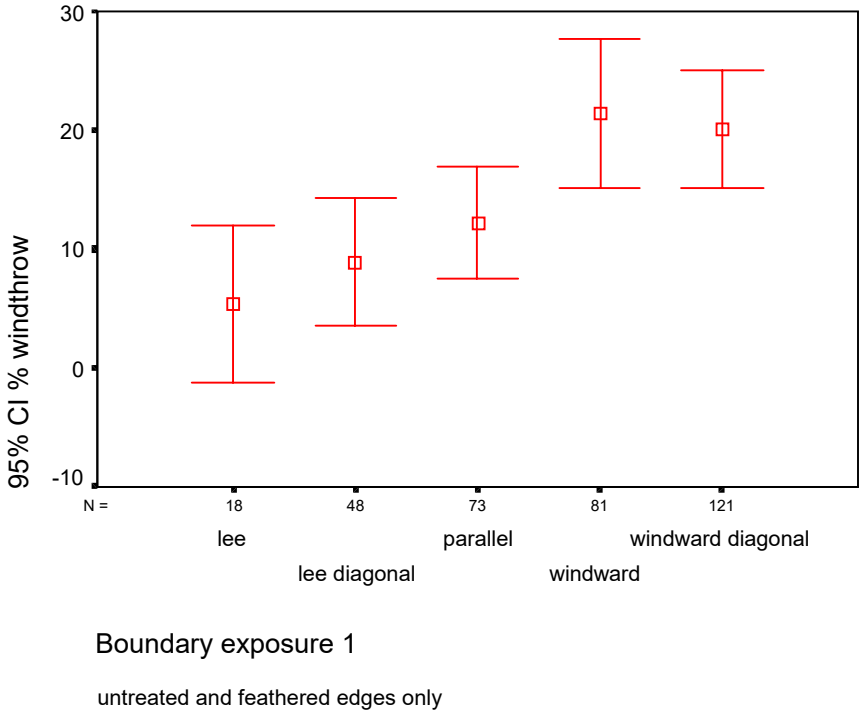


Figure 6 Windthrow distribution versus boundary exposure to wind

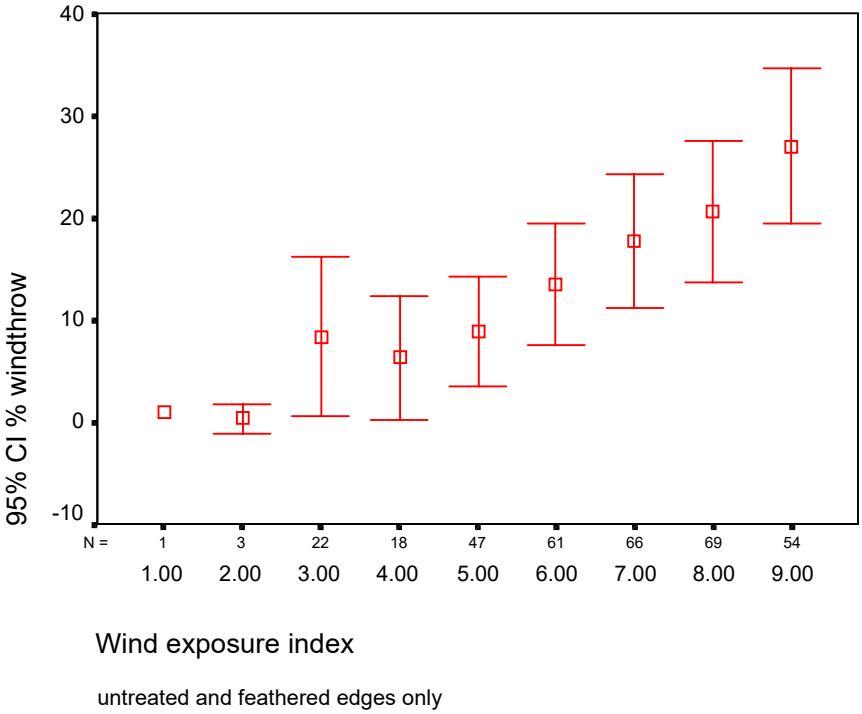


Figure 7 Windthrow distribution versus wind exposure index

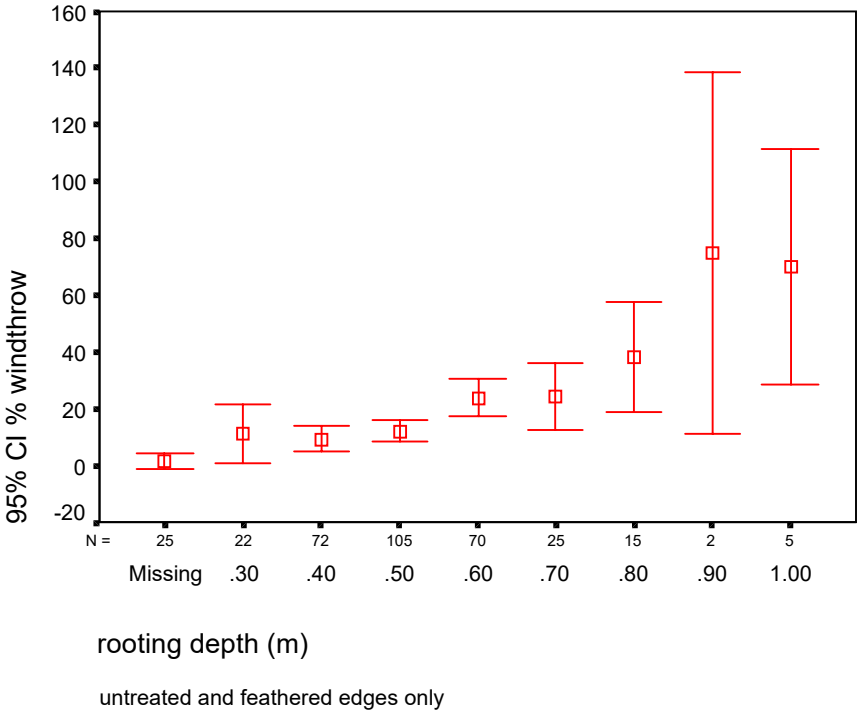


Figure 8 Windthrow distribution versus soil rooting depth

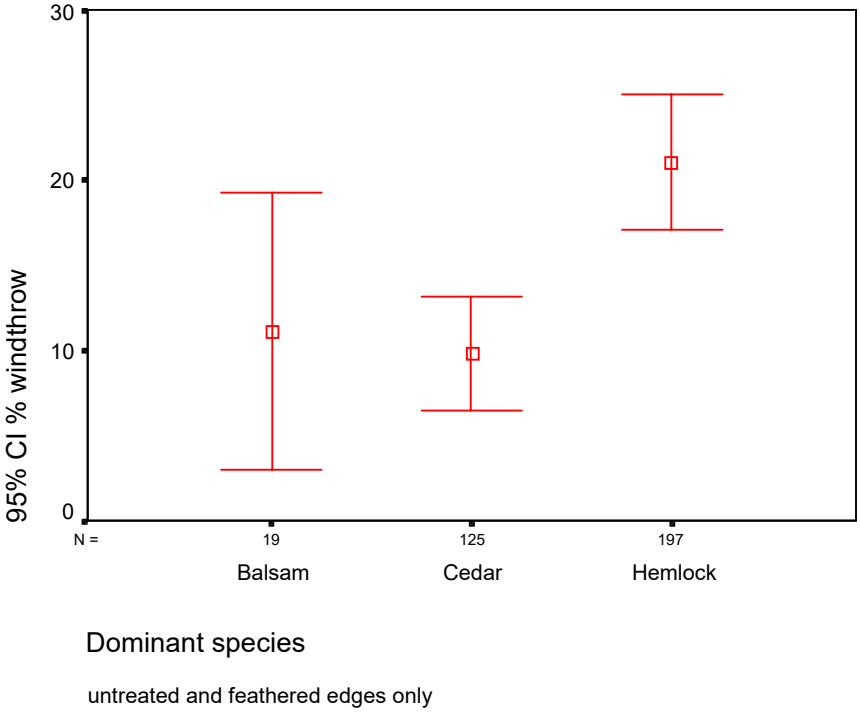
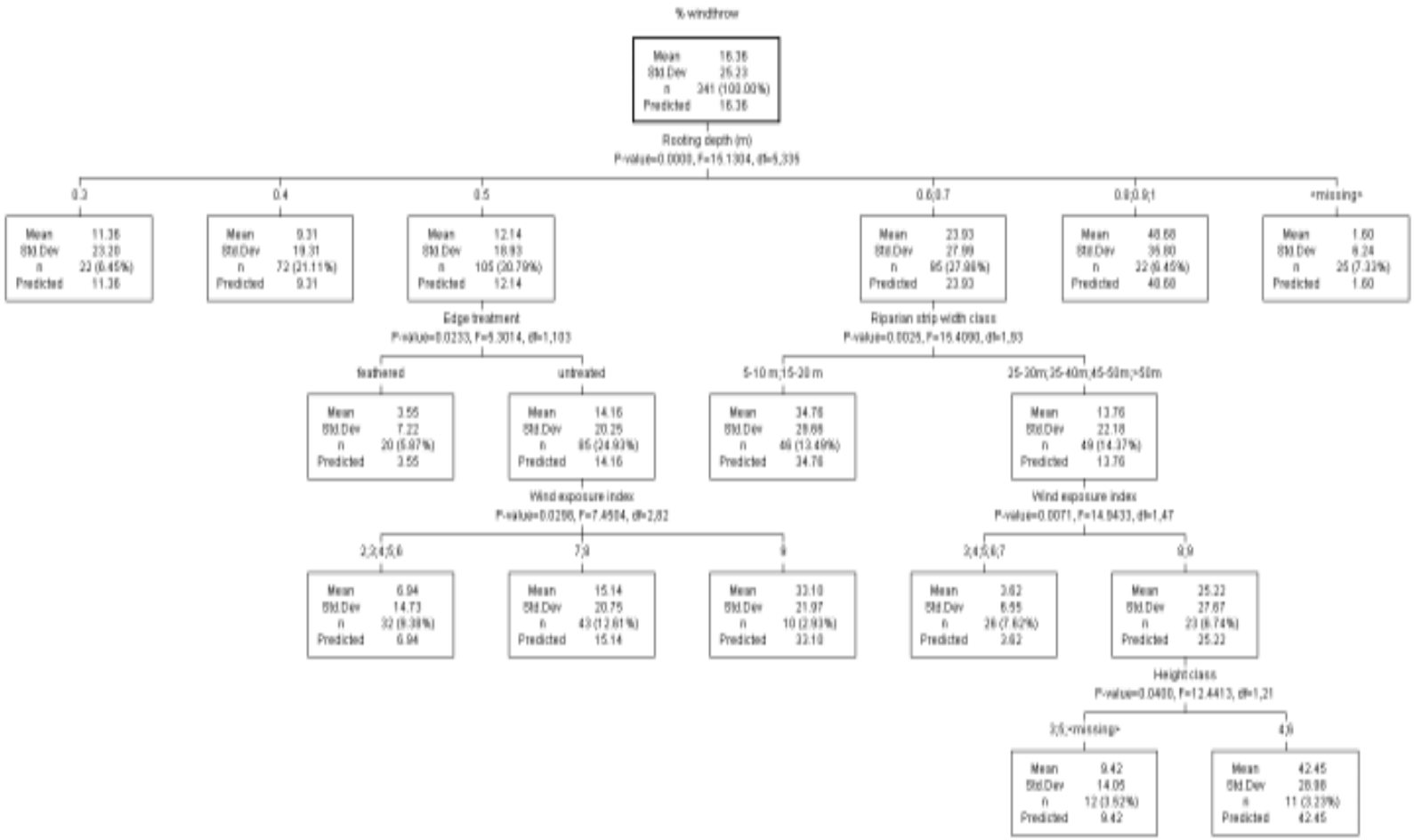


Figure 9 Windthrow distribution versus dominant trees species in riparian stands


% windthrow
Mean 16.36
Std.Dev 26.23
n 341 (100.00%)
Predicted 16.36
Rooting depth (m)
P-value=0.0000, F=16.1304, df=5,335
0.3
Mean 11.36
Std.Dev 23.20
n 22 (6.45%)
Predicted 11.36
0.4
Mean 9.31
Std.Dev 19.31
n 72 (21.11%)
Predicted 9.31
0.5
Mean 12.14
Std.Dev 18.93
n 105 (30.79%)
Predicted 12.14
0.6;0.7
Mean 23.93
Std.Dev 27.99
n 95 (27.88%)
Predicted 23.93
0.8;0.9;1
Mean 40.60
Std.Dev 35.80
n 22 (6.45%)
Predicted 40.60
<missing>
Mean 1.60
Std.Dev 6.24
n 25 (7.33%)
Predicted 1.60
Edge treatment
P-value=0.0233, F=5.3014, df=1,103
feathered
Mean 3.55
Std.Dev 7.22
n 20 (5.87%)
Predicted 3.55
untreated
Mean 14.16
Std.Dev 20.25
n 85 (24.93%)
Predicted 14.16
Riparian strip width class
P-value=0.0025, F=15.4090, df=1,83
5-10 m;15-20 m
Mean 34.76
Std.Dev 28.68
n 46 (13.49%)
Predicted 34.76
25-30m;35-40m;45-50m;>50m
Mean 13.76
Std.Dev 22.18
n 49 (14.37%)
Predicted 13.76
Wind exposure index
P-value=0.0288, F=7.4504, df=2,82
2;3;4;5;6
Mean 6.94
Std.Dev 14.73
n 32 (9.38%)
Predicted 6.94
7;8
Mean 15.14
Std.Dev 20.75
n 43 (12.61%)
Predicted 15.14
9
Mean 33.10
Std.Dev 21.97
n 10 (2.93%)
Predicted 33.10
Wind exposure index
P-value=0.0071, F=14.8433, df=1,47
3;4;5;6;7
Mean 2.62
Std.Dev 6.55
n 26 (7.62%)
Predicted 2.62
8;9
Mean 25.22
Std.Dev 27.67
n 23 (6.74%)
Predicted 25.22
Height class
P-value=0.0400, F=12.4413, df=1,21
3;5;<missing>
Mean 9.42
Std.Dev 14.05
n 12 (3.52%)
Predicted 9.42
4;6
Mean 42.45
Std.Dev 28.88
n 11 (3.23%)
Predicted 42.45

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Historic hybridization and persistence of a novel mito-nuclear combination in red-backed voles (genus Myodes)

Amy M Runck*[1], Marjorie D Matocq[2] and Joseph A Cook[3]

Address: [1]Department of Biological Sciences, Idaho State University, Pocatello, Idaho 83209, USA, [2]Department of Natural Resources and Environmental Science, University of Nevada, Reno, Nevada 89512, USA and [3]Biology Department and Museum of Southwestern Biology University of New Mexico, Albuquerque, New Mexico 87131, USA

Email: Amy M Runck* - arunck2@unl.edu; Marjorie D Matocq - mmatocq@cabnr.unr.edu; Joseph A Cook - cookjose@unm.edu

* Corresponding author

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Abstract

Background: The role of hybridization in generating diversity in animals is an active area of discovery and debate. We assess hybridization across a contact zone of northern (*Myodes rutilus*) and southern (*M. gapperi*) red-backed voles using variation in skeletal features and both mitochondrial and nuclear loci. This transect extends approximately 550 km along the North Pacific Coast of North America and encompasses 26 populations (n = 485). We establish the history, geographic extent and directionality of hybridization, determine whether hybridization is ongoing, and assess the evolutionary stability of novel genomic combinations.

Results: Identification of *M. rutilus* and *M. gapperi* based on the degree of closure of the post-palatal bridge was concordant with the distribution of diagnostic nuclear MYH6 alleles; however, an 80 km zone of introgressed populations was identified. The introgressant form is characterized by having mitochondrial haplotypes closely related to the northern *M. rutilus* on a nuclear background and morphological characteristics of southern *M. gapperi*.

Conclusion: Introgression appears to have been historic as pure populations of *M. rutilus* are now isolated to the north from introgressants or pure *M. gapperi* by the LeConte Glacier. As we do not find pure *M. rutilus* or *M. gapperi* individuals throughout the distribution of the introgressant form, it appears that the introgressants are a self-sustaining entity not requiring continued hybridization between pure parental forms to generate this novel combination of characters.

Background

The evolutionary significance of hybridization has been widely recognized in some taxa such as plants, but our understanding of how this process contributes to animal diversity, especially in vertebrates is relatively limited [1-3]. Ecological and demographic settings known to contribute to hybridization between otherwise well-defined species include newly established contact (such that behavioral, pre-zygotic filters to breeding may not exist) and low density of one or both parental species such that conspecific mating opportunities are limited [4]. Such biogeographic and demographic conditions are known to characterize many areas of interspecific, post-glacial contact where the leading edges of the expanding ranges of post-glacial colonizers meet [5-8]. Such regions provide a unique opportunity to examine the origin and maintenance of hybrid forms within an increasingly well-understood biogeographic and temporal framework.

Hybrid zones between species are thought to be maintained by two primary classes of models that predict 1) differential fitness between pure parental and hybrid individuals and 2) differential degrees of spatial overlap between pure parental species. The 'tension zone' model [4] posits a dynamic balance between selection against hybrids and dispersal of hybrids into the zone while the 'bounded superiority' model [9] holds that hybrids are superior to pure parental types in a limited set of environments. As such, the tension zone model necessitates continued generation of hybrid offspring from pure parentals so such systems would be characterized by sympatry of pure parental and hybrid forms on a spatial scale that encompasses the dispersal distances of the focal species. Alternatively, if hybrids have a selective advantage, even in a limited set of environmental conditions, we would predict little to no spatial overlap between pure parental and hybrid individuals. If the distribution of hybrid-appropriate habitat is at a scale that greatly exceeds the dispersal distance of pure parentals, maintaining occupancy of these areas would require that the introgressed form become independently sustaining. It is through this latter scenario that introgressive hybridization could establish stable, evolutionarily independent populations.

A particularly common hybrid form is a pattern of mitochondrial introgression leading to novel cytonuclear combinations. Because mitochondrial DNA is maternally inherited, this pattern can exist in animals where females are the homogametic sex (i.e. mammals). Due to reproductive inferiority of the heterogametic sex (Haldane's rule), the perpetuation of such novel cytonuclear combinations is prevented in animals with heterogametic females [10]. A plausible model for a pattern of mitochondrial introgression would be one wherein interspecific hybrids initially backcross with the most available pure parental species and then become a self-perpetuating entity, perhaps even displacing pure parentals. Under such a model, introgressant hybrids would be characterized by a mitochondrial genome of one parental taxon on a genomic background composed predominantly of that of a second taxon. Phylogenetic relationships and overall levels of diversity of mitochondrial types in the new introgressant hybrid form relative to the parental taxa could provide a great deal of insight into the origin of the introgressant form as well as subsequent factors contributing to the maintenance of these novel combinations.

Where the distributions of the northern red-backed vole (*Myodes rutilus*) and southern red-backed vole (*Myodes gapperi*) meet, we have an opportunity to examine interspecific interactions at the leading edge of two expanding ranges. As the ice sheets retreated, *M. rutilus* expanded its distribution south from Beringia, while *M. gapperi* colonized northward into Canada approximately 13,500 years before present (Ka) [11,12]. Hybridization between the two species has been hypothesized based on discordance between morphological and mitochondrial traits in a limited number of field-collected specimens [13], convergence in allozyme variation in areas of contact [14] as well as successful interspecific crosses in the laboratory [15]. Despite their capacity to interbreed, *M. rutilus* and *M. gapperi* are not sister lineages and are separated by approximately 9% sequence divergence in the mitochondrial cytochrome *b* gene [16]. Our goals were to 1) establish the geographic extent and directionality of any introgression between these taxa in southeast Alaska, 2) assess whether hybridization between *M. rutilus* and *M. gapperi* is ongoing and/or historic, and 3) assess the evolutionary stability of any novel genomic combinations.

Results

Post-palatal bridge morphology

There was a distinct break in character state of the post-palatal bridge near the Stikine River (Table 1). Individuals from Jap Creek (locality 7, Figure 1) and north had incomplete post-palatal bridges, which is the same character state observed in the *M. rutilus* from the reference sample (interior Alaska), and from throughout its range (Runck in prep). Individuals from Mallard Slough (locality 8, Figure 1) and south had complete bridges, characteristic of the *M. gapperi* reference sample (Minnesota) and from specimens of *M. gapperi* throughout its range (Figure 1; Runck in prep). There were, however, two individuals (localities 3 & 4), north of Mallard Slough that possessed complete post-palatal bridges, and two individuals (localities 14 & 23) south of Mallard Slough that had incomplete post-palatal bridges. In interior Alaska, 5 of 46 *M. rutilus* individuals had complete post-palatal bridges suggesting a low incidence of natural variation within this character in the northern red-backed vole.

Nuclear gene MYH6 genetic variation

Phylogenetic analyses of sequences of MYH6 revealed two clades with an average uncorrected pairwise divergence of 1.94% (Figure 2). Maximum likelihood, neighbor-joining, and Bayesian analyses produced similar topologies. Individuals from Jap Creek (locality 7) and northward had alleles that formed a clade with *M. rutilus* from western Alaska and Russia (Figure 2). Individuals from Mallard Slough (locality 8) and southward had alleles that formed a clade with *M. gapperi* from Minnesota and British Columbia. Uncorrected sequence divergence between the outgroup taxa and the *M. gapperi* and *M. rutilus* clades were 2.98% and 1.80%, respectively. None of the sequenced individuals was heterozygous at the diagnostic nucleotide positions.

Further sampling of the species-specific SNP using RFLP analyses resulted in the digestion pattern diagnostic of *M. rutilus* in all individuals from Jap Creek (7) northward, while all individuals from Mallard Slough (8) southward

Table 1: Sampling localities and number of individuals examined for morphological and molecular data

Locality		N	Cytochrome *b*		MYH6		Post-palatal bridge	
			rutilus	*gapperi*	*rutilus*	*gapperi*	*incomplete*	*complete*
Southeast Alaska *M. rutilus*								
1	Excursion Inlet	6	6	-	6	-	-	-
2	Mud Bay	20	20	-	20	-	7	-
3	Echo Cove	20	20	-	20	-	19	1
4	Limestone Inlet	8	8	-	8	-	3	1
5	Cape Fanshaw	18	18	-	18	-	4	-
6	Patterson River	13	13	-	13	-	9	-
7	Jap Creek	10	10	-	10	-	1	-
Southeast Alaska introgressants								
8	Mallard Slough	28	28	-	-	28	-	21
9	Stikine River	20	20	-	-	20	-	18
10	Berg Bay	5	5	-	-	5	-	3
11	Tyee	29	5	24	-	29	-	11
12	Reflection Lake	17	8	9	-	17	-	17
13	Unuk River	31	31	-	-	31	-	25
14	Chickamin River	15	10	-	-	10	1	14
15	Hut Point	16	4	12	-	16	-	15
Southeast Alaska *M. gapperi*								
16	Ledge Point	7	-	7	-	7	-	7
17	N Rudyerd Bay	17	-	17	-	17	-	11
18	Point Louise	19	-	19	-	19	-	14
19	Gwent Cove	20	-	20	-	20	-	17
20	Duck Point	26	-	26	-	26	-	3
21	Union Bay	25	-	24	-	24	-	12
22	Bond Bay	24	-	24	-	24	-	24
23	Wrangell Island	36	-	36	-	36	1	32
24	Etolin Island	34	-	20	-	20	-	24
25	Revillagigedo Is.	12	-	12	-	12	-	9
26	Revillagigedo Is.	9	-	9	-	9	-	6
Interior Alaska *M. rutilus*								
Denali Nat. Park		46	1	-	1	-	41	5
Minnesota *M. gapperi*								
Brown County		18	-	1	-	1	-	18

Individuals examined for morphological and molecular data. Locality numbers correspond to Figure 1. Numbers of individuals examined for cytochrome *b* and MYH6 include direct sequencing and RFLP analyses. Contact of *M. gapperi* and introgressants is found at localities 11, 12, and 15.

had MYH6 alleles diagnostic of *M. gapperi*. We found no individuals heterozygous for species-specific alleles.

Mitochondrial genetic variation and character concordance

We found 46 unique mitochondrial cytochrome *b* haplotypes in our entire sample. Patterns of variation across haplotypes were characteristic of functional mitochondrial genes, with average base frequencies of A (29.3) G (13.5) C (29.6) T (27.6), a 3.64 transition/transversion ratio, and a gamma distribution of 0.75 of changes across classes of codon sites. In addition, the distribution of the variable amino acid residues was consistent with the model of variable and conserved regions in cytochrome *b* [17].

Phylogenetic reconstruction using maximum likelihood, Bayesian, and neighbor-joining methods produced similar topologies consisting of two highly supported clades, A and B (bootstrap support of 100; Figure 3). Average pairwise sequence divergence between southeast Alaska individuals in clades A and B is 7.2% (uncorrected *p* distance). Clade A haplotypes extended from Siberia, through western Alaska, and along the southeast Alaskan coast north of Hut Point (15; Figure 3). Clade B haplotypes were found in Minnesota and British Columbia as well as the southeast Alaskan coast from Hut Point (15) southward to Gwent Cove (19) on the mainland, Tyee (11) to Bond Bay (22), on the Cleveland Peninsula, and Wrangell (23), Etolin (24), and Revillagigedo (25, 26) islands. Through additional RFLP screening of cytochrome *b*, we determined that all individuals north of the Stikine River (localities 1–8) and individuals up to 80 km south of the Stikine River (localities 9 – 15) had Clade A mitochondrial haplotypes. Clade B haplotypes were

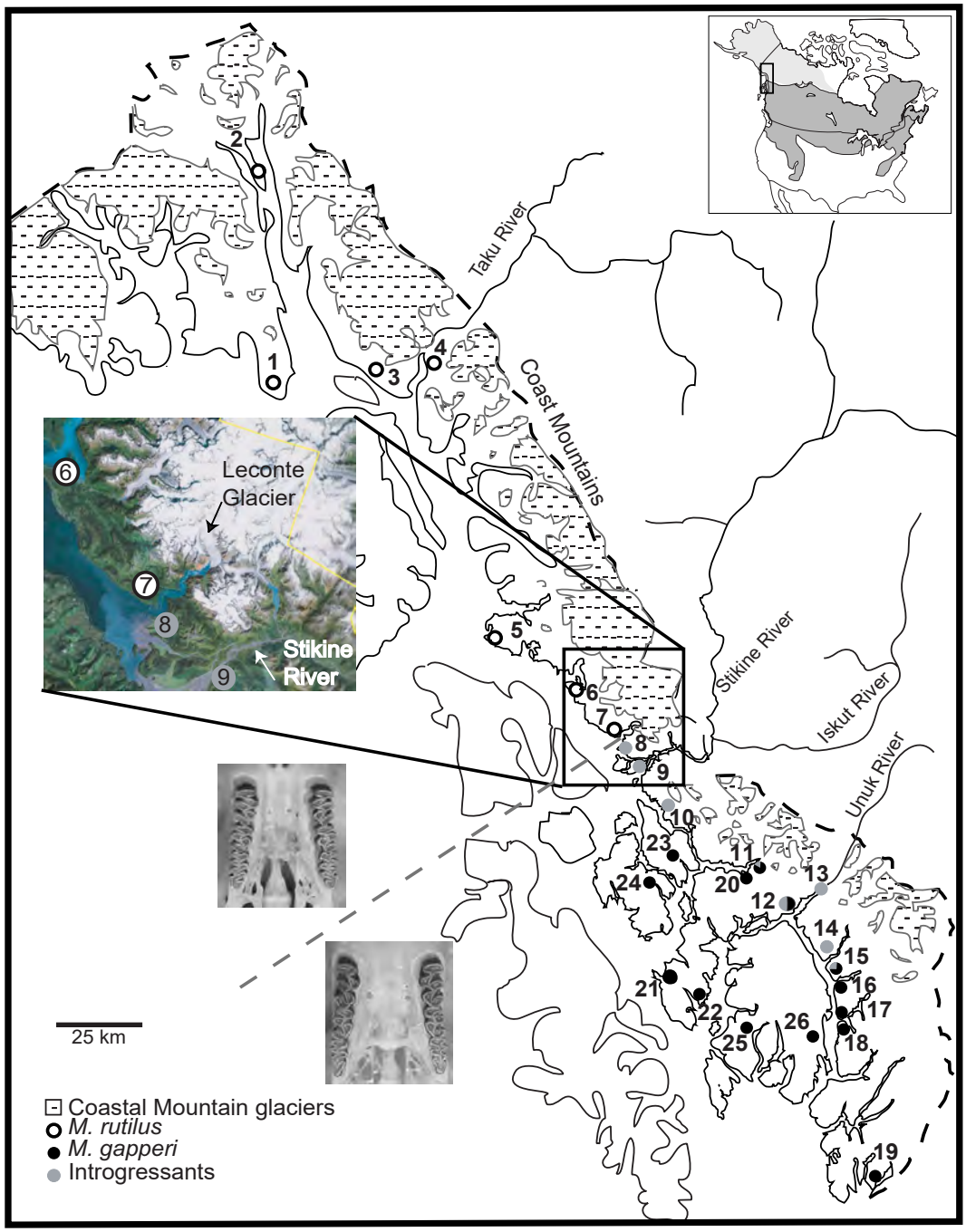

Figure 1

Distribution map of *Myodes rutilus*, *M. gapperi*, and introgressants in southeast Alaska. Open circles refer to individuals with post-palatal bridge morphology, cytochrome *b* haplotypes, and MYH6 alleles of *M. rutilus*. Black shaded circles refer to individuals with post-palatal bridge morphology, cytochrome *b* haplotypes, and MYH6 alleles of *M. gapperi*. Grey shaded circles refer to individuals with post-palatal bridge morphology and MYH6 alleles of *M. gapperi* and cytochrome *b* haplotypes of *M. rutilus*. Numbers correspond to population numbers in Table 1. The grey dashed line indicates change in post-palatal bridge morphology. Stippled areas indicate present-day glaciers. Inset of highlighted area is GIS glacial coverage that shows the LeConte Glacier extending to the coast, resulting in a physical barrier between populations 7 and 8.

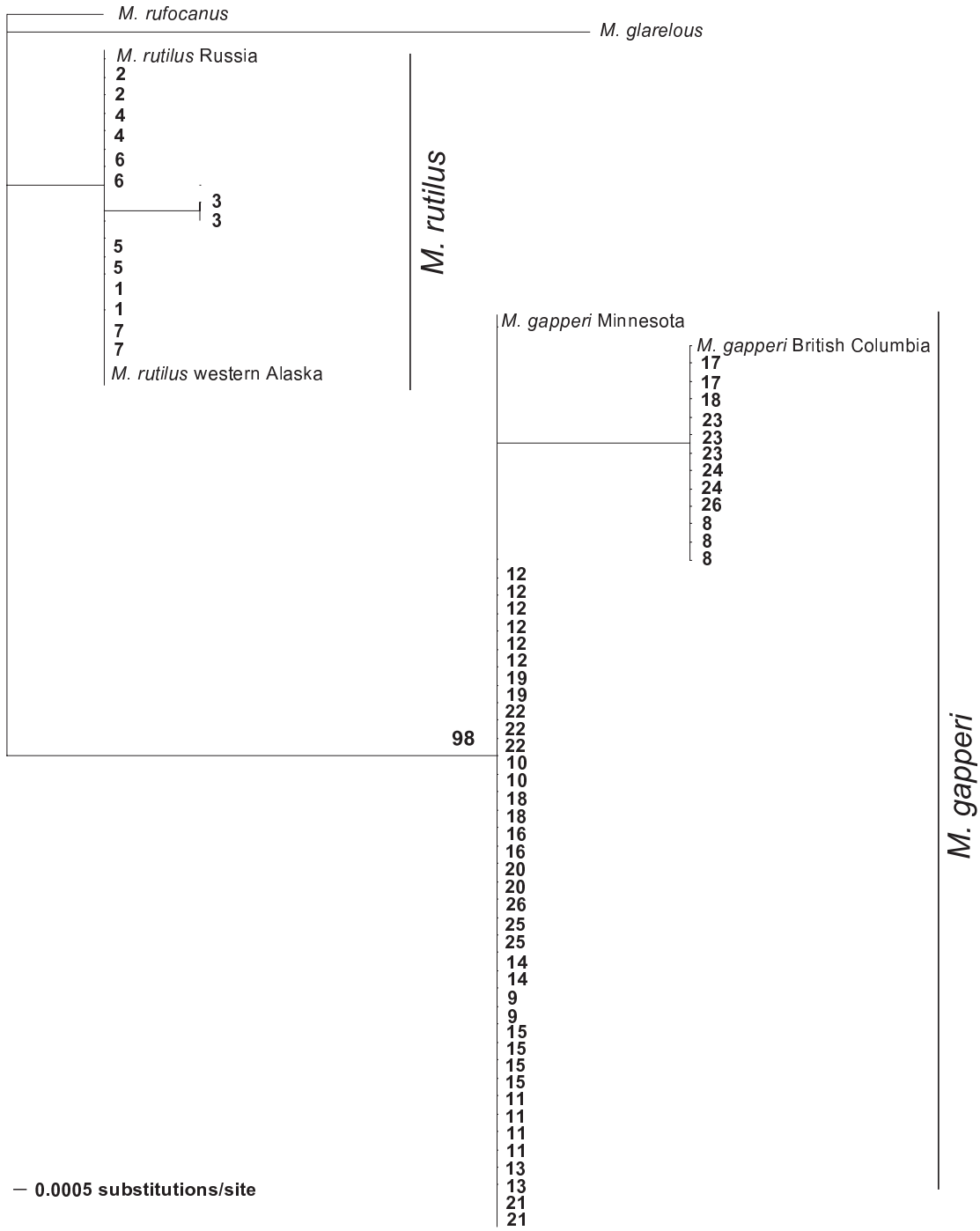

Figure 2

Maximum likelihood tree constructed with 257 bp of the MYH6 locus. Phylogeny was constructed using maximum likelihood and the HKY model of nucleotide substitution. Numbers above the branches are bootstrap support values > 65. Taxa labels are the locality number. The vertical bars show the morphological species identifications.

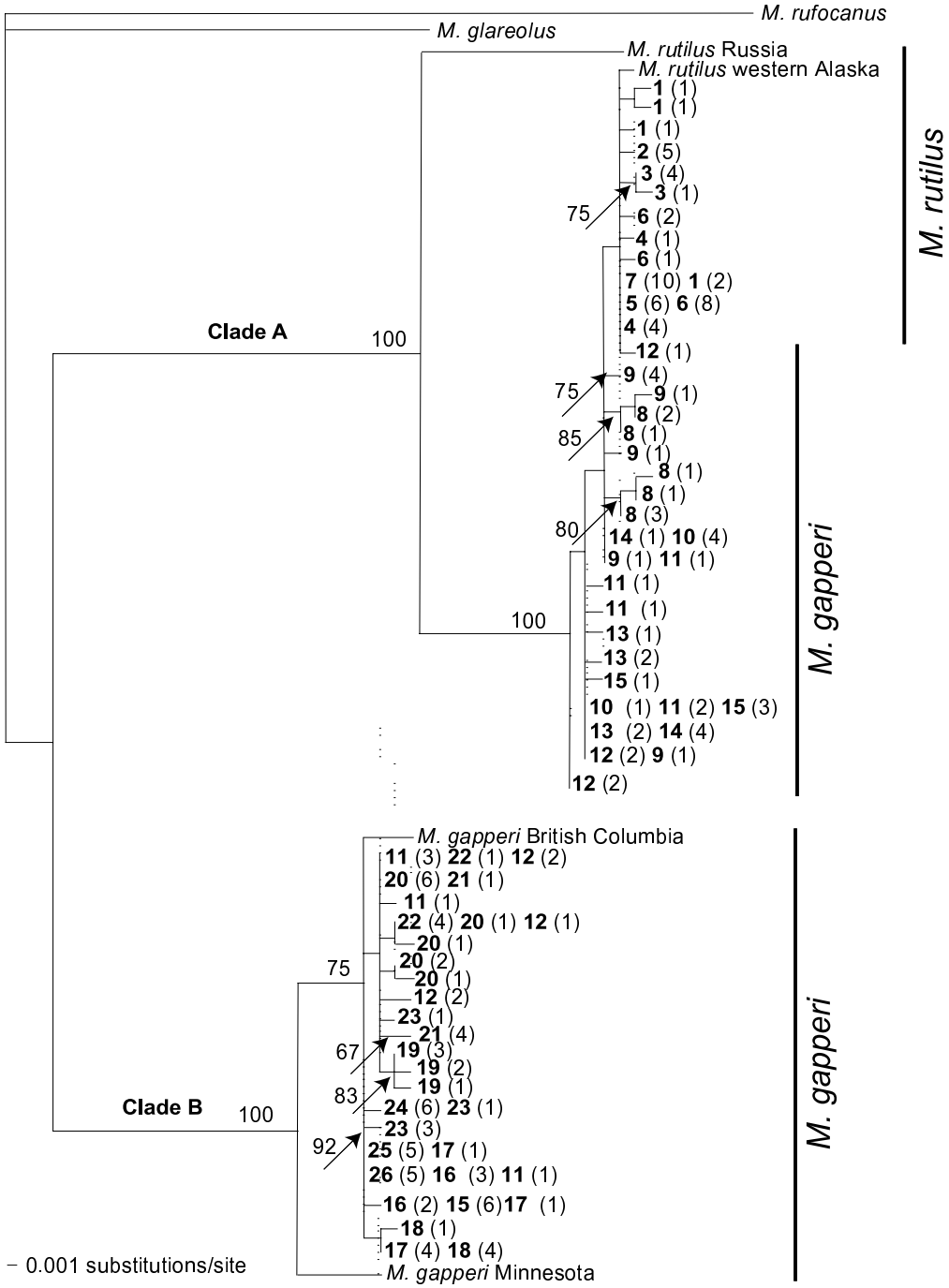

Figure 3

Maximum likelihood tree constructed with 600 bp of the cytochrome *b* gene. Phylogeny was constructed using the TrN + invariable sites + gamma model of nucleotide evolution. Number above the branches are bootstrap support values > 65. The taxa labels in bold are the locality number and the numbers in parentheses are the number of individuals. The vertical bars indicate the morphological species identifications.

found on the mainland south of Hut Point (localities 15 – 19), on the Cleveland Peninsula (localities 11, 12, 20 – 22) and on Wrangell (locality 23), Etolin (locality 24), and Revillagigedo islands (localities 25, 26). Contact between the two divergent haplotype clades were found at localities 11, 12, and 15.

Individuals with Clade A haplotypes that were also characterized by the post-palatal bridge morphology of *M. rutilus* and MYH6 alleles concordant with this morphology were only found north of Jap Creek (7). Hereafter, we refer to these individuals as *M. rutilus*. Individuals with Clade B haplotypes and the post-palatal bridge morphology of *M. gapperi* and MYH6 alleles concordant with this morphology were found on Etolin (23), Wrangell (24), Revillagigedo (25, 26) islands, the Cleveland Peninsula (20 – 22), and south of Hut Point (15), (hereafter *M. gapperi*). All individuals from Mallard Slough (8) south to Berg Bay (10) and Unuk and Chickamin rivers (13 & 14) had the post palatal bridge morphology and MYH6 sequence characteristic of *M. gapperi* but a set of cytochrome *b* haplotypes more closely related to pure *M. rutilus* (hereafter introgressants; Figure 1). Introgressants were found in sympatry with *M. gapperi* only at localities 11, 12, and 15 (Figure 1; Table 1). Though haplotypes found within the introgressant individuals as a group were most closely related to *M. rutilus*, none was identical to haplotypes found in populations of *M. rutilus*. A synapomorphic mutation (position 513) was shared by all but one individual (Reflection Lake; locality 12) of the 45 sequenced introgressants.

To further resolve haplotype relationships within the two major clades, we constructed statistical parsimony networks using cytochrome *b* sequence variation without violating the parsimony criterion, as haplotypes within each clade were ≤10 mutational steps away from each other. The Clade A network had two major subclades, one consisting of haplotypes only found in the introgressant form (Figure 4; indicated in grey) and the other consisting of all pure *M. rutilus* individuals and one introgressant (Figure 4). The maximum distance between pure *M. rutilus* individuals was five mutations (0.008%) and between introgressant individuals six mutations (0.01%). Two ancestral haplotypes were inferred in the Clade B network (internal nodes) and a maximum distance of 5 mutations (0.008%) was found among these *M. gapperi* haplotypes (Figure 5).

Haplotype diversity was highest in *M. gapperi* (0.906 +/- 0.01) and in the introgressants (0.874 +/- 0.04) and lowest in *M. rutilus* (0.633 +/- 0.07; Table 2). Likewise, nucleotide diversity was highest in *M. gapperi* and the introgressants (0.003 +/- 0.002) and lowest in *M. rutilus* (0.001 +/- 0.001). Even though the introgressant haplotypes are nested within *M. rutilus*, haplotype and nucleotide diversities in *M. rutilus* and the introgressants are significantly different $t_{\phi 0}$ = 18.22 p = < 0.001 and $t_{\phi 0}$ = 31.96 p = < 0.001, respectively.

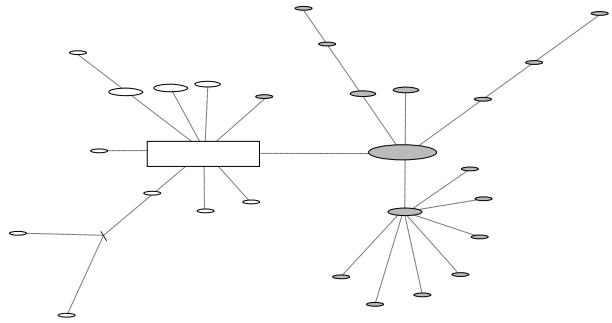

Figure 4
Cytochrome *b* gene genealogy of Clade A haplotypes. Statistical parsimony network was constructed using all unique Clade A haplotypes with the inferred ancestral haplotype indicated by the square. The size of the squares and ovals correspond to the haplotype frequencies. Haplotypes represented by white ovals (n = 11) were found in individuals identified as *M. rutilus* and haplotypes represented by grey ovals (n = 18) were found in individuals identified as introgressants. A hash mark indicates intermediate mutational steps. The parsimony criterion was met, as the number of mutational steps between any pair of haplotypes was ≤7.

Demographic history and molecular evolution

Values obtained through Fu's test of selective neutrality were largely negative and significantly different from zero (Table 2), which is expected for populations undergoing recent growth. However, negative values can also be a result of selection. The mismatch distributions were unimodal for *M. rutilus*, *M. gapperi*, and the introgressants, which is expected for populations undergoing sudden expansion or under certain selective regimes (Figure 6).

Estimates of the timing of any expansion events (τ) were very similar in *M. gapperi* and the introgressants, but more recent in *M. rutilus* (Table 2). The unimodal peak of the mismatch distributions (τ) were used to calculate time since expansion ($t = \tau/2u$), which we estimate to be 9.46 Ka (95% CI range 7.91 – 12.0 Ka) for *M. gapperi* and 8.57 Ka (95% CI range 5.86 – 11.95 Ka) for the introgressants. Estimate of time since expansion is most recent in *M. rutilus* at 4.31 Ka (95% CI range 2.12 – 6.74 Ka).

Relative rate tests were conducted using pairwise lineage comparisons and *M. rufocanus* as an outgroup. Because of saturation, rates of synonymous substitutions per synonymous site (Ks) could not be calculated, so rates of synony-

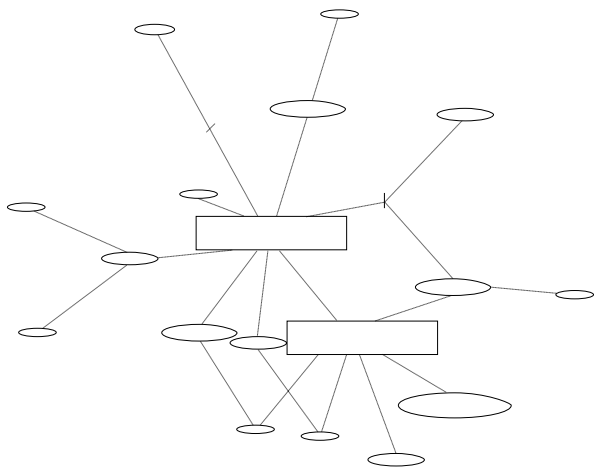

Figure 5
Cytochrome *b* gene genealogy of Clade B haplotypes. Statistical parsimony network was constructed using all unique Clade B haplotypes. These haplotypes were found in individuals identified as *M. gapperi*. Inferred ancestral haplotypes are represented by squares. The size of the square and ovals correspond to the haplotype frequencies. A hash mark indicates intermediate mutational steps. The parsimony criterion was met, as the number of mutational steps between any pair of haplotypes was ≤5.

mous transversions per fourfold degenerate site were estimated (B4), as the rate of evolution in transversions is slower. Pairwise lineage comparisons of B4 showed no significant difference among the rates of evolution ($p > 0.27$). Rates of non-synonymous substitutions per nonsynonymous site (Ka) were also similar among the lineages ($p > 0.30$; results not shown). The molecular clock hypothesis was not violated, as likelihood scores of trees constructed with and without molecular clock constraints were not significantly different ($\chi^2 = 44.8$ d.f. = 176, $P > 0.05$).

Discussion

After the retreat of Pleistocene glaciers, distributions of many high latitude organisms shifted resulting in new species assemblages and opportunities for genetic and ecological interactions [5-8,18]. Historical genetic signatures of heterospecific mitochondrial genes may be preserved in hybrid zone populations that are no longer undergoing genetic exchange. Examination of these populations using population and coalescent methods should provide insight into the timing and dynamics of geographical shifts in species' ranges in response to climate change [8,19].

Concordance of diagnostic characters

Identification of *M. rutilus* and *M. gapperi* in this transect based on the degree of closure of the post-palatal bridge was concordant 98.7% of the time with the distribution of the species-specific MYH6 alleles, with the exception of four individuals. The discordance observed in these individuals was a result of the character state of the post-palatal bridge being opposite of what was found in all other members of their respective population. We therefore reason that because there is a distinct change in the developmental state of the post-palatal bridge at the Stikine River area and this character distinguishes *M. rutilus* from *M. gapperi*. This abrupt change in frequency of the ossification of post-palatal bridge and distribution of the MYH6 diagnostic alleles coincides with Hall's [20] depiction of parapatry of *M. rutilus* and *M. gapperi* at the Stikine River area.

The distribution of highly differentiated mitochondrial cytochrome *b* haplotypes was not concordant with the morphological and nuclear characters. Our analysis revealed three groups: *M. rutilus* is characterized by an incomplete post-palatal bridge and a set of closely related MYH6 alleles and cytochrome *b* haplotypes; *M. gapperi* is characterized by a complete post-palatal bridge and a set of closely related MYH6 alleles and cytochrome *b* haplotypes that are highly differentiated from those of *M. rutilus* (1.9% and 7.2%, respectively); and an introgressant form that has the post palatal bridge and MYH6 alleles of *M. gapperi* but a set of cytochrome *b* haplotypes that is unique, yet clearly more closely related to *M. rutilus* haplotypes. Thus, across an 80 km expanse separating pure *M. rutilus* and *M. gapperi* populations, these introgressant red-backed voles are characterized by a combination of features of both *M. rutilus* and *M. gapperi*.

Table 2: Cytochrome *b* summary statistics for *M. rutilus*, *M. gapperi* and introgressants

Group	N	H	S	*h* ± SD	π ± SD	Fu's Fs	τ
M. rutilus	47	11	11	0.633 ± 0.07	0.001 ± 0.001	-7.8*	0.97 (0.48 – 1.51)
M. gapperi	80	18	16	0.906 ± 0.01	0.003 ± 0.002	-8.9*	2.13 (1.78 – 2.70
Introgressants	45	17	17	0.874 ± 0.04	0.003 ± 0.002	-11.3*	1.93 (1.32 – 2.69)

Diversity measures from the analysis of cytochrome *b* sequences. Number of individuals examined (N), number of haplotypes (H), number of segregating sites (S), gene diversity (*h*), nucleotide diversity (π), Fu's Fs, for *M. rutilus, M. gapperi*, and introgressants. Estimates of time since expansion in mutational units (τ) are calculated from the mismatch distribution with their 95% confidence intervals.
* Significant $p < 0.01$.

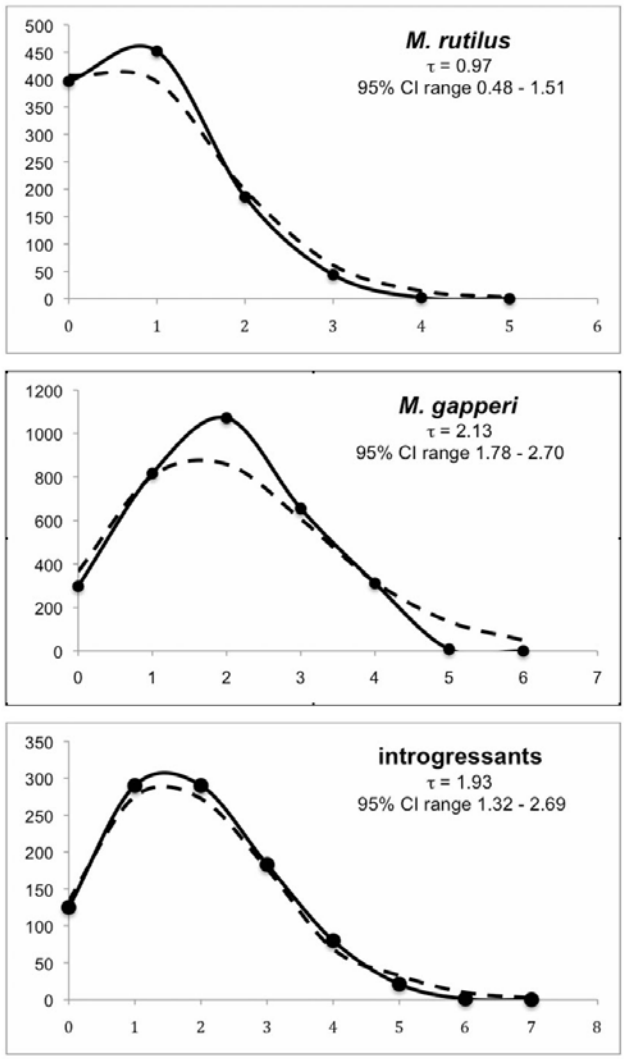

Figure 6
Mismatch distribution. Mismatch distribution for *M. rutilus*, *M. gapperi* and introgressants. The solid and dashed lines indicate observed and expected distributions, respectively.

Colonization and hybridization dynamics

Estimates of expansion times into southeast Alaska obtained from the mismatch distribution ($t = \tau/2u$) indicate that these species arrived post-glacially. Working under the assumption that rates of evolution are consistent among these three groups, estimates of time since expansion are similar in *M. gapperi* and the introgressants, dating to 9.46 Ka and 8.57 Ka, respectively. As introgressants largely reflect the genetic signature of the hybridizing *M. rutilus*, expansion of both species into southeast Alaska date back to the early Holocene [21,22]. These estimates of expansion into southeast Alaska are notably earlier than the expansion time of those pure populations of *M. rutilus* that now exist north of the LeConte Glacier (4.31 Ka).

Given our refined view of the distribution of *M. rutilus* and *M. gapperi* and potential barriers, there appears to be no contemporary contact between these species in this transect. Consistent with that view, is the lack of MYH6 heterozygotes with alleles diagnostic of pure *M. rutilus* and *M. gapperi* that might suggest ongoing hybridization with *M. rutilus* [23]. Likewise, inspection of the post-palatal bridge, presumably controlled by multiple nuclear loci, revealed no intermediate morphs.

In addition to not finding evidence for contemporary gene exchange between these two species, we did not find the parental species in sympatry. Furthermore, there was not extensive overlap of the introgressants with the pure parentals. *M. gapperi* and the introgressants occur in sympatry only at the southern edges of the zone of introgressants (localities 11, 12, 15), and the current tidewater position of the LeConte Glacier prevents contemporary contact of pure *M. rutilus* with voles in areas farther south that are now occupied by introgressants or, even farther south, by pure *M. gapperi*. As such, it would appear that the introgressants are self-sustaining populations and not hybrids that are continuously generated from pure parental crosses. An active contact zone does exist, however, at the southern, leading edge of the introgressant distribution and the northern edge of pure *M. gapperi* (at localities 11, 12, 15). The direction and degree of genetic exchange at the latter contact zone is the subject of an ongoing study (Runck et al., in prep). Future ecological studies should explore whether abiotic or biotic shifts are associated with the transition between these groups and/or whether direct competitive interactions limit their coexistence.

Origin of mitochondrial signature in introgressants

The introgressant form is characterized by a monophyletic group of mitochondrial haplotypes nested within haplotypes otherwise characteristic of *M. rutilus*. Nonetheless, the introgressed group possesses a distinct mitochondrial genetic signature from *M. rutilus* populations across this region. Notably, not only do the introgressants not share any haplotypes with *M. rutilus*, they also have significantly greater mitochondrial variability than the donor species.

Three plausible scenarios could lead to this distinct genetic signature of novel, but closely related, haplotypes and overall higher mtDNA diversity that characterize the introgressants. First, increased mitochondrial diversity in the introgressants may simply reflect differences in population history when compared to *M. rutilus* in southeast Alaska. The higher estimates of mitochondrial diversity in the introgressants are similar to those for other populations of *M. rutilus* outside of southeast Alaska. For 54 *M.*

rutilus found across a much greater geographic sampling area in northwestern Canada and interior Alaska, estimates are comparable to the level of diversity seen in the introgressants, with nucleotide diversity of 0.003, 19 segregating sites, and $\tau = 1.63$ (unpublished data). Therefore, it is possible that contemporary populations of *M. rutilus* in southeast Alaska previously had higher levels of diversity, but lost diversity (e.g., through bottleneck events) after hybridizing with *M. gapperi*. This hypothesis does not explain the lack of shared haplotypes between the introgressants and *M. rutilus*, however, so southeast Alaskan *M. rutilus* subsequently must have lost all the haplotypes now found exclusively in the introgressants.

A possible alternative is that southeast Alaska may have served as a glacial refugium during the Last Glacial Maximum for red-backed voles. Under this scenario, a more diverse population of *M. rutilus* originally hybridized with *M. gapperi* thus creating the introgressants, which captured and sustained *M. rutilus* haplotype diversity. As glaciers retreated, genetic diversity was lost from coastal populations of pure *M. rutilus* as they expanded northward (reflected in low mitochondrial variation in contemporary populations of *M. rutilus*). Although southeast Alaska has been proposed as a coastal refugium for vertebrates during Pleistocene glacial advances [24,25], we do not believe this is the case for northern red-backed voles again, because no introgressant haplotypes are shared with contemporary populations of *M. rutilus*.

A hypothesis that seems most consistent with the available data implicates multiple waves of colonization of *M. rutilus* into this coastal region. Multiple colonization events of *M. rutilus* into the region could also lead to this pattern of distinct haplotypes in the introgressants. Under this scenario, gene exchange between the species occurred first with an early colonizing population of *M. rutilus*, and the genetic signature of the introgressants now reflects this ancestral exchange along with the subsequent accumulation of new haplotypes through time. Later, a second colonization event would have given rise to extant *M. rutilus* in the region. If these extant-pure *M. rutilus* are indeed the result from a second, more recent colonization event, as the estimate of expansion suggests (~4.3 Ka), these voles would have been isolated from introgressant populations south of Jap Creek (locality 7) due to the advancement of the LeConte Glacier to tidewater around 5,000 ybp. Therefore, genetic exchange between the introgressants and contemporary *M. rutilus* would have been prevented and would account for the lack of shared cytochrome *b* haplotypes and lack of MYH6 heterozygotes. One would have to posit that the earlier colonizing wave of *M. rutilus* was extirpated from the region or was not sampled in this study.

Regional extinctions and multiple colonizations have been documented in southeast Alaska during times of climate oscillations [26] as the North Pacific Coast underwent repeated climatic fluctuations during the Pleistocene and Holocene. Recent advances correspond to the Younger Dryas around 10.6-9.9 Ka [27], with three additional advances around 5–6 Ka, 3.5-2.5 Ka, and 200-100 YBP [28-30]. During these cooling events, alpine glaciers advanced into lower elevations, reducing species ranges. Due to the extensive glacial coverage of the northern part of southeast Alaska, *M. rutilus* may have been susceptible to extirpation or displacement during periods of cooling and advancing glaciers.

Marginal support for the multiple waves of colonization of *M. rutilus* hypothesis is reflected in the relationship of the introgressant mtDNA relative to pure *M. rutilus* in the minimum spanning network and likelihood tree. In both analyses, introgressants form a subgroup, and are not intermixed with the remaining *M. rutilus* mitotypes suggesting that these two mitotypes were not part of a panmictic population. The genetic footprint of an earlier hybridization event supports the hypothesis of multiple colonizations of the northern red-backed vole along the coast.

Evolution of an introgressant contact zone

Although genetic exchange may have been extensive, our data suggest that a very closely related set of haplotypes (or a single haplotype that subsequently mutated) was captured and maintained in the introgressants. The unimodal distribution of pairwise comparisons and position of the introgressant haplotypes in the network and phylogeny support the hypothesis of a single hybridization event instead of multiple temporally discrete events. Initial genetic exchange may also have been bidirectional, but we only have evidence thus far of the mitochondrion of *M. rutilus* being maintained on the morphological and presumably nuclear background of *M. gapperi*. Nonetheless, a more complete view of the nuclear composition of the introgressant form relative to the pure parental forms will provide insight to the extent of backcrossing that occurred in this system.

Once established, the novel mito-nuclear combination of the introgressants either diffused neutrally or was selected for and expanded their distribution while displacing the pure parentals. While we cannot determine which scenario is responsible for the 80 km zone of introgressants, it is notable that all individuals in this region are introgressants. Moreover, several of our findings are consistent with predictions of the bounded superiority hypothesis [9]. The introgressants and pure parentals do not overlap extensively and the introgressants are self-sustaining and are not the result of continual hybridization. Also, consistent with the bounded superiority hypothesis is that the introgressants occupy a limited area of southeast Alaska, and have not established populations west of localities 11 and 12 on the Cleveland Peninsula.

Figure 7
Variation in ossification of the post-palatalbridge. Pictures of ventral views of craniums with arrows pointing to the medial shelf. A. Complete post-palatal bridge, with the dashed line highlighting the medial shelf connected to lateral parts of the palate; diagnostic of *M. gapperi*. B. Incomplete post-palatal bridge, with the dashed line highlighting the medial shelf, which is not connected to lateral parts of the palate; diagnostic of *M. rutilus*.

The degree of genetic admixture that may have occurred while the introgressant voles were fairly uncommon relative to pure parentals awaits our more complete sampling of the nuclear genome of this group. Similar long-term persistence and spatial expansion of introgressant or hybrid forms has been documented in snails (genus *Cerion*), resulting from an ancient hybridization event between a now extinct fossil species and an extant species [31]. Hybrids are hypothesized to have persisted due to the novel genetic combinations that enhanced survival during the time that one of the parental species was eliminated [31].

With the advance of the LeConte Glacier to tidewater approximately 5,000 years ago, any potential for gene flow between northern *M. rutilus* and the introgressants ceased. However at the southern edge, we do find localities (11, 12, and 15) where introgressants overlap spatially with pure *M. gapperi* suggesting the potential for ongoing gene flow. Ongoing analyses of microsatellite genetic variation should identify not only the degree of overall distinction between the introgressed form and pure *M. gapperi* but also the amount of gene flow that characterizes their current contact zone. Likewise, ecological studies may help identify the degree to which these groups compete either directly or indirectly with one another and whether the spatial distribution of each is currently stable or actively shifting.

A North Pacific Coast suture zone

The North Pacific Coast has been documented as post-glacial contact zone for several mammalian lineages from the high latitude refugium called Beringia and from multiple refugia that existed south of the continental ice sheets [13]. Within species, independent colonizations into this recently deglaciated region have occurred by at least two divergent lineages of several species such as dusky shrew (*Sorex monticolus*) [32], long-tailed vole (*Microtus longicaudus*) [33], black bear (*Ursus americanus*) [34], and marten (*Martes americana*) [35,36]. Ermine (*Mustela erminea*) are represented by three divergent lineages in southeast Alaska; one is hypothesized to be endemic to the region, perhaps surviving in the North Pacific Coast during the Pleistocene [24].

Introgression along the coast has been documented from divergent lineages of marten [35], black bears [37], and now red-backed voles. Contact zones are likely for divergent clades of dusky shrews and long-tailed voles, therefore the narrow strip of mainland along the southeast Alaska coast may be a suture zone, whereby several formerly isolated species have entered the region by discrete colonization routes, and have subsequently come into contact in the same geographic area [38-40]. The North Pacific Coast, and in particular, southeast Alaska, possess characteristics [38] commonly tied to suture zones, such as being located between Pleistocene glacial refugia, and nearby low mountain passes acting as corridors for dispersal [13,41] during warm periods.

A renewed interest has emerged in testing the validity of Remington's thirteen North American suture zones through phylogeographic studies [39,40,42]. The North Pacific Coast was not originally identified as a suture zone by Remington [38], but phylogeographic studies repeatedly demonstrate the existence of multiple lineages within species (e.g., shrews, voles) in this region. Populations representing divergent lineages are now in contact there following postglacial expansion [43]. Most of these studies, however, have limited ability to detect hybridization because only mitochondrial genes were assessed. Future phylogeographic studies of these species should employ multiple independent characters to more rigorously assess the influence of geologic and climatic events on structuring diversity along the North Pacific Coast.

Conclusion

Interspecific hybridization between *M. rutilus* and *M. gapperi* resulted in the formation of an introgressant group that spans 80 km. The novel mito-nuclear combination of these introgressants likely expanded either by displacing or by colonizing areas left unoccupied by pure parentals in response to the changing climate of the Holocene. Hybridization between the two species is historical, as a region occupied exclusively by the introgressants now separates these two species. Additionally, physical separation (as a result of glacial advances) of *M. rutilus* and introgres-

sant populations occurred ca. 5,000 Ka thus establishing reproductive isolation of this pure parental species and the introgressants. These introgressive populations appear to be stable as they are not a result of continuous interspecific matings between the pure parental species.

Methods

Sampling

The temperate rain forest of coastal southeast Alaska is naturally fragmented by extensive icefields, fjords, and six major rivers, and is isolated from continental North America by the St. Elias and Coast Mountains. Sampling was conducted at 26 localities [44] spanning approximately 550 km along the North Pacific Coast centered on the Stikine River where *M. rutilus* and *M. gapperi* are traditionally depicted as being in contact [20] (Figure 1). Specimens were deposited at the University of Alaska Museum of the North. A total of 485 individuals (see Additional file 1) were analyzed, with 5 to 36 individuals from each locality. Additional individuals of *M. rutilus* and *M. gapperi* from localities outside southeast Alaska were included for comparative purposes.

Morphological data collection

Closure of the post-palatal bridge is the key diagnostic character used to distinguish *M. rutilus* from *M. gapperi* (Figure 7) [11,20,45,46]. All individuals from the transect were examined, but in some instances the character state could not be determined due to skull damage, resulting in a total 328 individuals analyzed. Character states were compared with *M. rutilus* skulls from interior Alaska (n = 46) and *M. gapperi* skulls from Minnesota (n = 18). Previous analyses of these specimens and others show that degree of post-palatal closure is not correlated with sex, age, or latitude, (Runck in prep). Specimens were examined under 25× magnification to score the post palatal bridge either as A) complete, with medial shelf connected to lateral parts of the palate, or B) incomplete, with medial shelf disconnected (Figure 7).

Molecular methods

Genomic DNA was extracted from frozen liver of 95 *M. rutilus* and 390 *M. gapperi* following a modified salt extraction method [24,47].

Nuclear locus, MYH6

Twenty-seven nuclear genes were screened from the collection of comparative anchor tagged sequences to obtain a diagnostic nuclear perspective on species identification and to test for interspecific gene flow in the contact zone [48]. Five loci yielded PCR products in the 300–1000 bp range. We used the primer set MYH2F and MYH2R to generate a 257 bp fragment of MYH6 (myosin heavy polypeptide 6). Although this primer set was originally designed to amplify MYH2 (myosin heavy polypeptide 2) [48], a nucleotide BLAST search against the entire nucleotide collection in GenBank indicated that the amplified fragments are MYH6.

The identification of species-specific alleles was conducted using broadly distributed individuals of *M. rutilus* from Russia, Finland, and western Alaska and individuals of *M. gapperi* from Washington, Minnesota, and North Carolina. Outgroup taxa *M. rufocanus* and *M. glareolus* were also sequenced [16]. From these samples we found three conserved single nucleotide polymorphisms (SNPs) that distinguish the alleles of *M. rutilus* and *M. gapperi*. We consider this locus to be diagnostic for the two species because these diagnostic nucleotide differences were found throughout the species' ranges.

The MYH6 locus was amplified for all individuals (n = 485). Restriction length polymorphism (RFLP) analysis of the MYH6 locus was used to delimit the distribution of species-specific alleles among individuals. A restriction site is present at one of the SNPs, and the restriction enzyme Hpa II was used to digest MYH6 amplicons. Hpa II cuts the restriction site CCGG, which is present in *M. gapperi* at positions 182 – 185, but not in *M. rutilus*. Restriction enzyme digestion was completed using 5 μl of the PCR product, 7.5 units Hpa II, and 5 μl Buffer1 (New England Biolabs). PCR products were incubated at 37°C for 5 hours with negative and positive controls. Digested products were run on 2% agarose stained with ethidium bromide.

Directing sequencing of MYH6 was conducted on at least 2 individuals from each sampling locality (n = 64; Additional file 1; GenBank FJ638345–FJ638410). Qiagen Qiaquick purification kits were used to purify PCR products. Purified PCR products were cycle sequenced using Taq DyeDeoxy Terminator Cycle Sequencing Kit and Big Dye Terminator Cycle Sequencing Ready Reaction Mix 3.0 (Applied Biosystems Incorporated). Sequencing products were filtered using Sephadex G-50 in Centrisep spin columns (Princeton Separations). Automated sequencing of both heavy and light strands was conducted on Applied Biosystems Incorporated 373 and 3100 DNA sequencers. Sequences were aligned and compared manually using Sequence Navigator, Version 1.01 (Applied Biosystems Incorporated) and Sequencher (GeneCodes). Heterozygous sites were given standard DNA degenerate codes [23].

Mitochondrial locus, cytochrome b

PCR was used to amplify the first 632 base pairs of the cytochrome *b* gene with the primers MVZ 05 [49] and CLETH 06 [50] following established protocols [50]. Cytochrome *b* fragments were used in subsequent restriction enzyme digestions and direct sequencing.

Direct sequencing of the cytochrome *b* gene fragment was conducted on at least five individuals from each sampling locality (Additional file 1), resulting in a total of 47 sequences of *M. rutilus* and 125 of *M. gapperi* (GenBank FJ616001–FJ616166). Additional sequences were generated from one *M. rutilus* from Russia and one from western Alaska, and from one *M. gapperi* from British Columbia. Cytochrome *b* PCR products were purified using polyethylene glycol (PEG) precipitation [51]. Purified PCR products were cycle sequenced using Taq DyeDeoxy Terminator Cycle Sequencing Kit and Big Dye Terminator Cycle Sequencing Ready Reaction Mix 3.0 (Applied Biosystems Incorporated). Sequencing products were filtered using Sephadex G-50 in Centrisep spin columns (Princeton Separations). Automated sequencing of both heavy and light strands was conducted on Applied Biosystems Incorporated 373 and 3100 DNA sequencers. Sequences were aligned and compared manually using Sequence Navigator, Version 1.01 (Applied Biosystems Incorporated) and Sequencher (GeneCodes).

RFLP analysis was conducted on all individuals (n = 485) to determine the distribution of *M. rutilus* and *M. gapperi* cytochrome *b* gene haplotypes within the 26 populations. The ALU I restriction site AGCT is present in *M. rutilus* at position 513 but not in *M. gapperi* [16,50]. Cytochrome *b* fragments were digested using 3.5 units of ALU I, 1.0 ul Buffer2 (New England BioLabs), and 5.0 ul PCR product. Positive and negative controls were included to confirm enzyme activity in each trial. PCR products were digested for 5 hours at 37°C and then visualized on a 2.0% agarose gel stained with ethidium bromide. Digestion of the cytochrome *b* fragment resulted in two bands for *M. rutilus* and one band for *M. gapperi*. Distributions of the two haplotypes were mapped.

Phylogenetic analysis

We analyzed 257 bp of the MYH6 locus using maximum likelihood and neighbor-joining algorithms in PAUP*b10 [52] and Bayesian statistics in Mr. Bayes v3.4 [53]. Individuals of *M. rutilus* from western Alaska and Russia and individuals of *M. gapperi* from Minnesota and British Columbia were also included in the analyses. *M. rufocanus* and *M. glareolus* sequences were included as outgroups. The model HKY [54] was determined as the simplest model that best fit these data through Modeltest [55] and was used in the analyses. Neighbor-joining analyses used 1000 bootstrap replicates to assess nodal support. The Bayesian analysis started with a random tree and was run for 1.0×10^7 generations sampling every 1,000 generations. A consensus of three runs was computed after stationarity was reached.

The first 600 base pairs of cytochrome *b* from 172 southeast coastal individuals were used in phylogenetic analyses. *M. rutilus* from Russia and western Alaska and *M. gapperi* from British Columbia were included in addition to a published sequence from Minnesota [GenBank:AY952173] [50]. *M. rufocanus* [GenBank:AY309416] [16] and *M. glareolus* [GenBank:AF119272] [56] were included as outgroups. The Tamura-Nei [57] model of nucleotide evolution with invariable sites (0.4036) and gamma distribution (0.7468) was identified using Modeltest as the model that best fit these data, and was used in subsequent analyses. Phylogeographic relationships were reconstructed using maximum likelihood and neighbor-joining algorithms in PAUP*b10 [52]. Nodal strength was assessed using 1000 bootstrap replicates. Bayesian statistics were also used to reconstruct phylogeographic relationships in Mr. Bayes v3.4 [53]. Bayesian reconstruction started from a random tree and was run with four heated chains for 1.0×10^7generations, sampling every 1,000 generations. Three runs were conducted and nodal support (posterior probability) was computed from the three runs after stationarity was reached.

Two cytochrome *b* statistical parsimony networks were constructed for the two clades of haplotypes [58]. Haplotypes were connected based on the absolute number of mutational differences and coalescent theory was used to identify ancestral (internal) and derived (tip) relationships [59] in the program TCS v1.21 [60]. Ten mutational steps between any two haplotypes is the maximum difference allowable in order to reconstruct the relationships while meeting the parsimony criterion with 95% probability [58].

The *M. rutilus* haplotype network was constructed using 11 haplotypes representing 47 *M. rutilus* individuals and also included 17 *M. rutilus*-like haplotypes found in 45 individuals identified morphologically as *M. gapperi* (introgressants). The *M. gapperi* haplotype network was constructed using 18 haplotypes representing 80 *M. gapperi* individuals.

Demographic history and molecular evolution

Variation of cytochrome *b* sequences was used to test for signals of population expansion, to estimate the time since expansion, and to estimate mutation rates. Haplotype diversity (h) and nucleotide diversity (π) were estimated [61] separately for *M. rutilus*, *M. gapperi*, and introgressants in the program Arlequin ver. 3.11 [62]. Differences in levels of diversity were tested using a *t*-test. The frequency distribution of pairwise differences (mismatch distribution) [63] and Fu's F_S statistic [64,65] were calculated to test for population expansion in Arlequin ver. 3.11. Under the Sudden Expansion Model, pairwise differences will have a unimodal distribution [66]. Values of Fu's F_S will be negative and indicative of expansion when there is an excess of singleton mutations or a when a gene is under selection [65].

The peak of the unimodal distribution (τ) [66,67] in the mismatch distribution was used to calculate time since expansion in Arlequin. Applying the equation $\tau = 2\ \mu t$ where μ is the mutation rate and t is time in generations [66], allows an estimate of time since expansion. Confidence intervals of τ were calculated using parametric bootstrapping [68]. Using the mutation rate of 7.5% per million years [69], and values of τ obtained from mismatch analyses, we estimated time since expansion for *M. gapperi*, *M. rutilus* and introgressants.

To test for constancy in rates of cytochrome *b* evolution among lineages, we conducted a relative rates test in rrTree v1.1 [70], which calculates synonymous and non-synonymous rates of evolution [71,72]. We also constrained the ML phylogeny to a molecular clock in PAUP*4.0b10 [52] and performed a log likelihood ratio test of log likelihood scores of constrained and unconstrained trees and compared these values to a χ^2 distribution.

Authors' contributions

AMR designed the study, conducted fieldwork, generated the genetic data, examined the morphological variation in the post-palatal bridge, performed all statistical analyses, and wrote the manuscript. MDM provided fellowship support to AMR and contributed to the preparation of the manuscript. JAC assisted in designing the study, supported the fieldwork, and contributed to the preparation of the manuscript. All authors read and approved the final manuscript. Molecular research was conducted in laboratories of JAC and MDM.

Additional material

Additional file 1

Specimens examined in this study. *List of specimens and their voucher numbers used in this research.*
Click here for file
[http://www.biomedcentral.com/content/supplementary/1471-2148-9-114-S1.docx]

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forest policy

Implementing the 2012 Forest Planning Rule: Best Available Scientific Information in Forest Planning Assessments

C.M. Ryan, L.K. Cerveny, T.L. Robinson, and D.J. Blahna

National forests and grasslands in the United States are governed by land and resource management plans that should be updated every 15 years to reflect changing social, economic, and environmental conditions and to address new priorities. A new forest planning rule finalized in 2012 introduces new planning approaches and requirements, and several forests have completed the forest assessment phase of their planning process. Using document analysis and interview data, we analyzed four completed forest assessments to gain insights into early forest planning efforts under the 2012 rule. We found that forest assessments address the required topics, although the organization and depth of treatment varies across cases; government sources and academic publishers are relied on most often as sources of scientific information; and approaches to best available scientific information rely on peer-reviewed information, agency technical reports and syntheses, and personal expertise and judgement.

Keywords: early adopter, expertise, US Forest Service

Management of the 154 national forests and 20 grasslands in the United States is governed by land and resource management plans (also called forest plans), as required by the National Forest Management Act of 1976 (NFMA; 16 U.S.C. 1604). The forest plan functions as a guiding document that outlines goals, objectives, and strategies for management of the unit. Periodically, the rule related to forest planning is revised to reflect societal changes, new approaches and technologies, and scientific discoveries. For many years the US Forest Service (USFS), which manages the system of national forests and grasslands, has operated under a planning rule finalized in 1982 (47 FR 43026) despite several efforts (2000, 2005, and 2008) to revise and improve the rule (Schultz et al. 2013). A new planning rule issued in April 2012 (77 FR 21161) introduces several significant changes, including a renewed emphasis on collaboration, improved transparency, and a strengthened role for public involvement throughout the planning process. Of interest for our study is the requirement to use the best available scientific information (BASI) to inform the assessment, plan revision decisions, and monitoring program.

To date, little research has addressed implementation of the 2012 planning rule. Schultz et al. (2013) examined approaches to wildlife conservation planning under the new rule, raising concerns regarding potential extirpation of species. Another study analyzed public participation processes in 12 national forests (University of Montana 2015), and Schembra (2013) explored the role of standards and guidelines and how they are used in planning activities. Forest planning under the 2012 rule consists of three phases (assessment, plan development, and monitoring). The assessment phase is important, as it assembles relevant scientific information that planners will rely on to make decisions on forest management in the plan development phase. Our study contributes to this growing body of knowledge by examining the assessment phase of the forest planning process.

Eight "early adopter" national forests, along with several other forests, are currently developing their forest plans using the 2012

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Affiliations: *C. M. Ryan (cmryan@uw.edu) University of Washington, School of Environmental and Forest Sciences, Box 352100, Seattle, WA 98195-2100. L.K. Cerveny (lcerveny@fs.fed.us) USDA Forest Service, Pacific Northwest Research Station, 400 N. 34th St. Suite 201, Seattle, WA 98103. T.L. Robinson (Trob1701@uw.edu) University of Washington, School of Environmental and Forest Sciences, Box 352100, Seattle, WA 98195-2100. D.J. Blahna (dblahna@fs.fed.us) USDA Forest Service, Pacific Northwest Research Station, 400 N. 34th St. Suite 201, Seattle, WA 98103.*

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rule. These forests were designated as early adopters because they provide important benefits, had strong existing collaborative networks in place, and needed to revise their forest plans (USDA Forest Service 2012a). The eight early adopter forests are: Cibola (NM), Chugach (AK), El Yunque (PR), Nez Perce and Clearwater (ID), and three forests that are coordinating planning on a regional basis: Inyo, Sequoia, and Sierra (CA).

Although implementation is still in early stages, several of the early adopter forests have completed their forest assessments and draft forest plans, which presents an opportunity to study implementation of the planning process under the new rule. One forest (the Francis Marion in SC) has completed the full plan revision process as of this writing. We examined four forests that have completed their assessments, including three forests identified by the agency as early adopters and one forest that is keeping pace with this group. The study explored three questions: 1) What does the 2012 planning rule require regarding the structure, content, and process for forest assessments? 2) How have forests implemented the directives related to forest assessments under the 2012 planning rule? 3) How are forests approaching the requirement for the use of best available scientific information in their assessments?

Forest Planning under the 2012 Rule

The 2012 planning rule suggests an adaptive approach to forest planning, instructing managers to 1) *assess* forest conditions; 2) *revise or amend* plans if the assessment indicates a need for change; and 3) *monitor* plan implementation (36 CFR 219.5). The process is cyclical, with monitoring data feeding back into the assessment of conditions in the management unit (USDA Forest Service 2012b). During the assessment phase, planners are expected to "rapidly evaluate existing information about relevant ecological, economic, and social conditions, trends, and sustainability, and their relationship to the land management plan within the context of the broader landscape" (36 CFR 219.5(a)(1)). The second phase of the planning process is plan development, amendment, or revision, where planners use the results of the assessment to establish a need for change and generate planning alternatives (36 CFR 219.5(a)(2)), and the public has the greatest opportunity for input. The plan development phase includes environmental impact assessment, public input, and plan publication (36 CFR 219.5(a)(2)). The third phase (monitoring) is an opportunity to track and measure management effectiveness over time (36 CFR 219.5(a)(3)). The planning *process* under the 2012 rule is similar to the process specified under the 1982 rule, but differs in terms of the specific elements required for the *assessment* (2012 rule) and the *analysis of the management situation* (the assessment's counterpart in the 1982 rule).

We focused our study on the assessment phase of the planning process. The assessment phase is important because it requires the forest to assemble and synthesize the most recent, relevant, and highest-quality science on social, ecological, and economic conditions to inform the plan development. Not only does this provide planners an opportunity to evaluate changes in biophysical and socio-economic conditions based on the latest monitoring data, it also represents a chance to reflect on new concepts, models, and methods that result in new scientific information about the local forest environment. Under the 2012 planning rule, the assessment phase identifies existing conditions, trends, risks, uncertainties, and information gaps that are relevant to land and resource management issues in the unit (36 CFR 219.5–219.6). In the assessment phase, the planning unit is not required to generate new studies or information, but is expected to obtain pre-existing information that is publicly available or voluntarily provided (36 CFR 219.6). Information can come from government and nongovernment sources, and the rule instructs the Forest Supervisor to provide opportunities for stakeholders to provide information for the assessment (36 CFR 219.6). The primary product of the assessment phase is an assessment document that evaluates existing information for 15 specific topic areas (Figure 1). Although the general topic areas are mandated by the 2012 rule, the Forest Supervisor has discretion to determine the scope, scale, and timing of the assessment, assuming the other requirements in the planning rule are followed (36 CFR 219.6).

Role of Science in Natural Resource Management

Historically, natural resource management in the United States was guided by the idea of scientific management and Progressive-era approaches (Taylor 1896). In particular, Samuel Hays's "gospel of efficiency" relied on a rational and scientific method of making decisions through a single, central authority. The thought was to avoid conflict via a scientific approach to social and economic issues (Hays 1959, p. 267). The US Forest Service exemplifies the approach of technical rationality and empirical science as the basis for sound resource management practices (Wellman 1987; Kaufman 1960). Foresters and natural resource managers

Management and Policy Implications

Although implementation of the US Forest Service's 2012 planning rule is still in the early stages, several national forests have completed the assessment phase and moved on to the next phase of forest planning. Our analysis of forest assessments from several "early adopter" forests illustrates that forest planners are making serious efforts to address required topics and rely on the best available scientific information. Assessment reports were disproportionately heavy in science related to terrestrial and aquatic ecosystems, and more limited in treatment of infrastructure, land ownership and access patterns, cultural heritage, and areas of tribal importance. Ensuring that assessment teams include broad and diverse disciplinary experts will help address this challenge, recognizing that some forests may not have access to necessary disciplinary specialists. It is also possible that some of the topics (e.g., ecosystem services, tribal and cultural resources, land status and use patterns) simply do not have as much relevant and available information as other topics. Assessment teams may want to consider additional ways to interact with scientists and others to create functioning communities of practice related to science exchange for forest planning. In the same way, agency scientists may consider forging new and enduring relationships with planners and managers that could generate new science that is of immediate relevance. We found similarities across all forests in the most common approaches to identifying BASI in addition to other approaches such as data sharing meetings, a wiki review site, and requests for a science synthesis. Information from non-peer-reviewed sources was more difficult for planners to assess and evaluate. Sharing best practices, along with revised guidance for planning rule implementation, may help national forest planners improve the utility, efficiency, and quality of forest assessments.

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- Terrestrial ecosystems, aquatic ecosystems, and watersheds
- Air, soil, and water resources and quality
- System drivers, including ecological processes, disturbance regimes, and stressors
- Baseline carbon stocks
- Threatened, endangered, proposed and candidate species; potential species of concern
- Social, cultural, and economic conditions
- Benefits people obtain from the planning area (ecosystem services)
- Multiple uses and their contributions to economies
- Recreation settings, opportunities, and access, and scenic character
- Renewable and nonrenewable energy and mineral resources
- Infrastructure (recreational facilities, transportation and utility corridors)
- Areas of tribal importance
- Cultural and historic resources and uses
- Land status, ownership, use, and access patterns
- Existing designated areas including wilderness and wild and scenic rivers; need and opportunity for new designations

Figure 1. Topics for forest plan assessments (36 CFR 219.6)

are expected to incorporate state-of-the-art scientific knowledge to manage public lands (Lachapelle et al. 2003). However, the role of science in natural resource decision-making has become much more complex (Mills and Clark 2001). Recent literature acknowledges that no important policy issue or decision is purely technical, that established practices are problematic, and that politics are unavoidable (Brunner et al. 2005). In spite of this, numerous policies reflect the scientific management paradigm in their calls for best available science.

In the United States, many policies and statutes contain references to best available science, including the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and the Safe Drinking Water Act of 1974. Despite references to the concept of best available science, these policies do not include specific definitions of its properties, standards, or practical application in the decision-making process (Doremus 2004; Smallwood et al. 1999), leading to different definitions of what it means. Ryder et al. (2010) identify attributes of best available science from published literature that span topics such as endangered species legislation, protection of conservation areas, forest management, water resource management, and ocean fisheries. The paper highlights the diversity of attributes assigned to best available science, and demonstrates that no single attribute is common to all studies, suggesting that best available science is context specific (Ryder et al. 2010). Moreover, as Lowell and Kelly (2016) observe, the ability to use best available science may be inhibited by institutional constraints within particular agencies limited by time or organizational capacity. Other literature has attempted to assign descriptors to the concept. For example, "best" often connotes scientific information with the greatest degree of excellence and authenticity based on sound logic (Moghissi et al. 2010), or that there is no better scientific information, and suggests the use of the most relevant and contemporary data and methods (National Research Council 2004). "Available" connotes scientific information that is accessible and attainable (Moghissi et al. 2010), or that decisions can be consistent with the scientific information that is available even though data gaps exist (National Research Council 2004). "Science or Scientific information" is defined as knowledge that emerges from a process of observation, identification, description, and testing of explanatory hypotheses about fundamental principles that govern cause-and-effect (National Research Council 2004). The National Research Council report includes guidelines for effectively using best available science, including concepts of relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review. Finally, Charnley et al. (2017) analyzed a science synthesis for three national forests and suggest criteria for evaluating "best available *social* science," which may be different from the criteria used to evaluate best available biophysical science.

A key aspect of the 2012 planning rule is that it requires the planning process to draw on the best available scientific information (36 CFR 219.3). The preamble to the planning rule notes that there is a range of information that can be considered BASI, stating:

> In some circumstances, the BASI would be that which is developed using the scientific method, which includes clearly stated questions, well-designed investigations and logically analyzed results, documented clearly and subjected to peer review. However, in other circumstances the BASI for the matter under consideration may be information from analyses of data obtained from a local area, or studies to address a specific question in one area. In other circumstances, the BASI also could be the result of expert opinion, panel consensus, or observations, as long as the responsible official has a reasonable basis for relying on that scientific information as the best available. (77 FR 21192 [April 9, 2012])

Planning Directives are agency guidance documents that direct implementation of rules such as the 2012 planning rule, and directives for assessments are in Chapter 10 of the Land Management Planning Handbook (USDA Forest Service 2015a). The definition of BASI is contained in the "zero code" chapter of the handbook and specifies three primary criteria for determining BASI: accuracy, reliability, and relevance (FSH 1909.12.07.12), in addition to referencing the Data Quality Act (PL 106–554) for guidance on evaluating available information (Figure 2). Available is defined as information that currently exists in a form useful for the planning process without further data collection, modification, or validation (FSH 1909.07.01).

The directives also provide guidance regarding sources of scientific information. The sources mentioned in the guidance include peer-reviewed articles, scientific assessments, other scientific information (expert opinion, panel consensus, inventories, or observational data), data prepared and managed by the Forest Service

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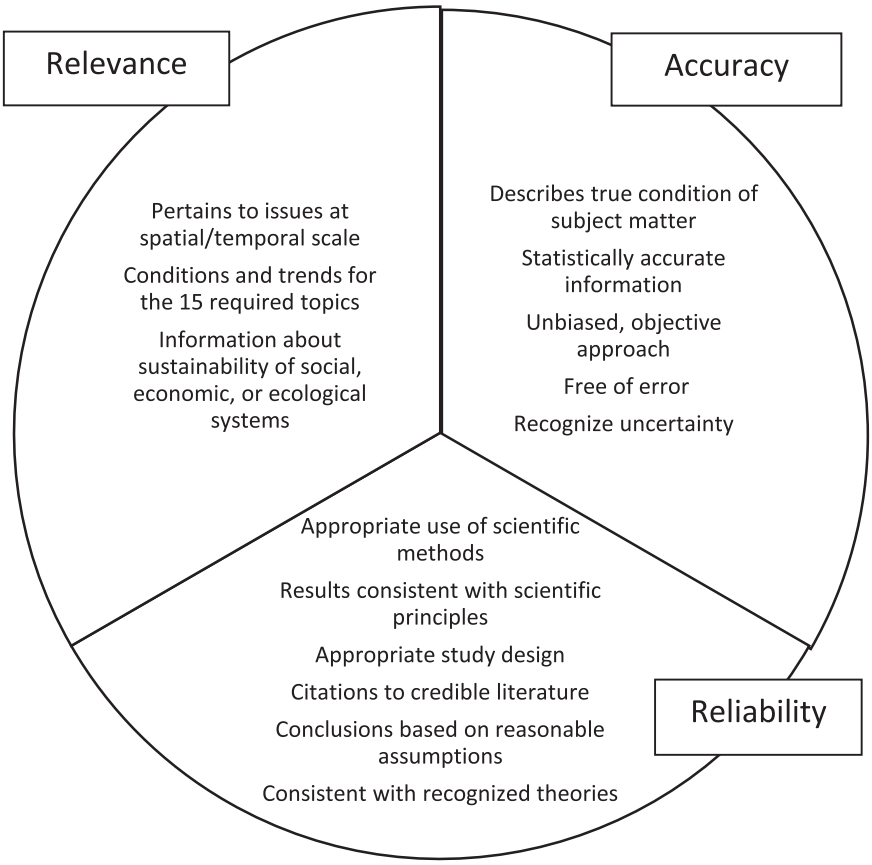

Figure 2. Criteria for determining best available scientific information (BASI). Source: Forest Service Handbook 1909.12.07.12

or other federal agencies, information prepared by universities, national research networks, and other reputable scientific organizations, and data or information from public and governmental participation (FSH 1909.12.07.13).

At the US Forest Service, two regional science synthesis efforts were initiated to assist forest planners in identifying BASI for their assessments. The first synthesis included the Sierra Nevada, southern Cascades, and Modoc plateau areas of California, and informed plan revisions on three national forests (Long et al. 2014). The second synthesis is currently underway as part of the Northwest Forest Plan area planning process, which covers 17 national forests and five Bureau of Land Management units across parts of the Cascade and coastal ranges of Washington, Oregon, and northern California. Once drafted, the synthesis report underwent independent third-party peer review, in addition to public review, and is currently under revision (Spies et al. 2017). Science synthesis efforts represent a noteworthy approach to developing BASI for use in forest assessments, creating a role for public engagement, and for employing a bioregional approach to assembling the latest science for use by multiple forests.

Methods

We used an exploratory case study approach to examine four national forest planning units that were revising their forest plans under the 2012 rule. Information on the USFS website helped us determine the planning status of each national forest as of spring 2015. The primary selection criterion was completion of the assessment process by spring 2015. We also strove to select national forests from different regions. Based on these criteria, we selected the Chugach National Forest (Alaska), Cibola National Forest (New Mexico), Inyo National Forest (California), and the Nantahala and Pisgah National Forests (North Carolina). Table 1 displays characteristics of each national forest planning unit in our sample.

Our research approach relied on content analysis of documents and interview data. We began by conducting a chapter-by-chapter analysis of each forest's assessment report to identify and characterize the information presented. We recorded page counts for each of the 15 assessment topics specified in the 2012 rule. In some cases, the chapters directly aligned with the required topics (Figure 1). In other cases, we had to make a more subjective characterization of the chapter contents. We also noted and analyzed any references to the use of best available science.

Second, as part of the document review, we analyzed data sources used in the assessment. For each assessment report, we identified all of the items cited in the reference section. We then coded each cited item according to the type of publishing entity and the type of document. Every cited item was placed in one category for each coding exercise. For each cited item, we determined the appropriate categories by examining the information in the citation entry and (when necessary) directly reviewing the item or gathering information on the publishing entity. We grouped publishing entities into five types: government; non-government; scientific, scholarly, or peer-reviewed; universities; and unknown or other (Table 2). This categorization approximates the rigor of scientific review, but there is overlap in categories. Most scholarly journals require a double-blind peer-review process, where reviewers and authors are

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Table 1. Characteristics of national forests in the study.

Management unit(s)	Geography	Total acreage* (millions of acres)	Notes on use and resources	Designated early adopter?	Most recent previous plan revision	Notes on current plan revision
Chugach National Forest Alaska Region (R10)	Southcentral Alaska: major geographic areas are Cooper River, Prince William Sound, and eastern Kenai Peninsula	6.26	Subsistence, timber, recreation, mining. Human use concentrated in Kenai area. Very limited road coverage and use in other areas. Habitat for all 5 Pacific salmon species	Yes	2002	Managed by a planning team housed within unit
Cibola National Forest Southwest Region (R3)	West-Central New Mexico: Eight noncontiguous parcels organized around distinct mountainous areas known as "sky islands"	2.11	Recreation, timber, cultural heritage, range. Surrounding region experiencing population growth and demographic changes. Pinyon-juniper & ponderosa pine are predominate vegetation types	Yes	1985	Managed by a planning team housed within unit. Does not include 4 associated national grasslands
Inyo National Forest Pacific Southwest Region (R5)	Eastern California & West Nevada: Two noncontiguous parcels at intersection of Sierra Nevada, Great Basin, and Mojave Desert areas	2.07	Water supply, hydroelectricity, recreation, timber, range. Nearly 47% of total area is wilderness. Focus on wildland fire management. Substantial variation in vegetation type, habitat, and elevation	Yes	1988	One of three early adopters in R5. Coordination through a regional planning team, with separate planning teams for each unit. Each unit releases its own assessment & forest plan. Joint EIS for 3 units
Nantahala & Pisgah National Forests Southern Region (R8)	Western North Carolina: Blue Ridge region of Appalachian Mountains	2.48	Timber, recreation, cultural/historical heritage, water development. Located in Blue Ridge National Heritage Area. Hardwood forest with high species diversity	No	1987	Both units will use same revised plan. Managed by planning team housed at NF in NC headquarters

*Total acreage includes NFS-owned land and acreage under other ownership within each unit. Source: USDA Forest Service 2015b.

Table 2. Categories for coding type of publishing entity.

Publishing entity	Description of coding criteria
Government	Federal, tribal, state, or local governments in the United States; foreign governments; international intergovernmental groups such as the United Nations and affiliates. Includes peer-reviewed and non-peer-reviewed materials
Non-government	Materials not published by a government agency, university, or peer-reviewed entity. Includes businesses, consulting firms, and advocacy groups
Scientific scholarly or peer reviewed	Associations, societies, journal publishers, university presses, or other entities that produce peer-reviewed scientific or scholarly material
Universities	Materials from universities that may or may not be subject to rigorous academic peer review. Includes university or college departments, programs, laboratories, and centers, and theses and dissertations from universities
Unknown or other	News organizations or other undefined groups; disposition of publisher could not be determined

unknown to each other. University and government agency scientific documents often require peer review, but the level of rigor of the review may be variable. It was not possible to discern the level or type of peer review or scientific rigor for each category.

For the type of document, we sorted the references into 12 categories: academic book; non-academic book; conference proceeding; correspondence; database; scientific journal; news; technical report; statute or regulation; thesis or dissertation; website; and unknown (Table 3).

Our final data collection activity was qualitative interviewing with members of the planning teams at three of the forests in our study. We conducted nine semi-structured interviews (nine people in total; three interviews each from three forests). Unfortunately, we were not able to recruit interview participants from the Cibola planning effort. Potential interview participants were identified through the list of preparers included in each assessment document. Interviewees were subject matter experts who had contributed material to the assessment reports, along with planning staff officers or coordinators. Interview questions explored the overall structure of the assessment process, the role of the planning directives, the overall organization of the forests' plan revision efforts, and approaches to identification and use of best available science. Interviews were audio-recorded, transcribed, and analyzed using content analysis with a coding framework developed by the study team. Content analysis is a method that uses codes, or labels that assign meaning to descriptive or inferential data collected during a study (Miles et al. 2014). The codes are used to retrieve and organize similar data and aid the researcher in relating data to research questions, theoretical concepts, and themes (Araujo 1995; Miles et al. 2014).

Results

We present results of our analysis in three sections: 1) required topics; 2) sources and types of information; and 3) identifying and using BASI.

Required topics in the forest assessment

The number and percent of pages devoted to each required topic is presented in Table 4. We did not include introductory front matter in the page counts. A 0* entry means that the assessment report did not

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Table 3. Categories for coding type of document.

Document type	Description of coding criteria
Academic book	An item printed, bound, distributed as a book, or released as an e-book by a peer-reviewed/scholarly entity
Non-academic book	An item printed, bound, distributed as a book, or released as an e-book by an entity whose primary orientation is not peer reviewed/scholarly
Conference proceeding	Papers, abstracts, and talks presented at a conference and published in a conference proceeding collection
Correspondence	Letters or emails written by individuals of any affiliation
Database	Raw data or data analysis tools/software; online databases
Scientific journal	A peer-reviewed article in a scholarly journal
News	Articles in newspapers (print or online) and news magazines
Technical report	Technical and research reports, white papers, policy papers, fact sheets, briefings
Statute, regulation, and planning documents	Federal, state, or local laws and rules; EISs; management plans; strategic plans
Thesis or dissertation	Advanced degree projects and papers
Website	One or more webpages on a non-database website, including encyclopedias with narrative entries
Unknown	The type of document could not be discerned

Table 4. Page counts and percentages of total pages for 15 required assessment topics.

		Number of pages (pct. of total pages in report)				Pct.
Topic #	Assessment topics (per 36 CFR 219.6)	Chugach	Cibola	Inyo	N&P	Avg.
1	Terrestrial ecosystems, aquatic ecosystems, and watersheds	66 (22.9%)	51.5 (11.2%)	38.5 (21.0%)	29 (15.7%)	**17.7**
2	Air, soil and water resources and quality	17 (5.9%)	88 (19.2%)	9 (4.9%)	19 (10.3%)	**10.1**
3	System drivers (processes, disturbance regimes, and stressors)	40 (13.9%)	21 (4.6%)	15 (8.2%)	7 (3.8%)	**7.6**
4	Baseline carbon stocks	7 (2.4%)	6 (1.3%)	4 (2.2%)	7 (3.8%)	**2.4**
5	Threatened, endangered, candidate species; potential species of conservation concern	12 (4.2%)	36 (7.9%)	24 (13.1%)	4 (2.2%)	**6.8**
6	Social, cultural, and economic conditions	21 (7.3%)	71 (15.5%)	14 (7.7%)	8 (4.3%)	**8.7**
7	Benefits obtained by people (ecosystem services)	49 (17.0%)	0* (0.0%)	2.5 (1.4%)	4 (2.2%)	**5.1**
8	Multiple uses and their contributions to economies	0* (0.0%)	26 (5.7%)	15 (8.2%)	17 (9.2%)	**5.8**
9	Recreation settings, opportunities, and access, and scenic character	29 (10.0%)	39 (8.5%)	15.5 (8.5%)	21 (11.4%)	**9.6**
10	Renewable and nonrenewable energy and mineral resources	17 (5.9%)	18 (3.9%)	3.5 (1.9%)	8 (4.3%)	**4.0**
11	Infrastructure	2 (0.7%)	12 (2.6%)	9.5 (5.2%)	10 (5.4%)	**3.5**
12	Areas of tribal importance	2 (0.7%)	13 (2.8%)	4.5 (2.5%)	3 (1.6%)	**1.9**
13	Cultural and historical resources and uses	3.5 (1.2%)	40 (8.7%)	7 (3.8%)	23 (12.4%)	**6.6**
14	Land status and ownership, use, and access patterns	8 (2.8%)	17 (3.7%)	7 (3.8%)	9 (4.9%)	**3.8**
15	Designated areas, potential/need for new designations	15 (5.2%)	20 (4.4%)	14 (7.7%)	16 (8.7%)	**6.5**
	TOTAL	**288.5**	**458.5**	**183**	**185**	**100**

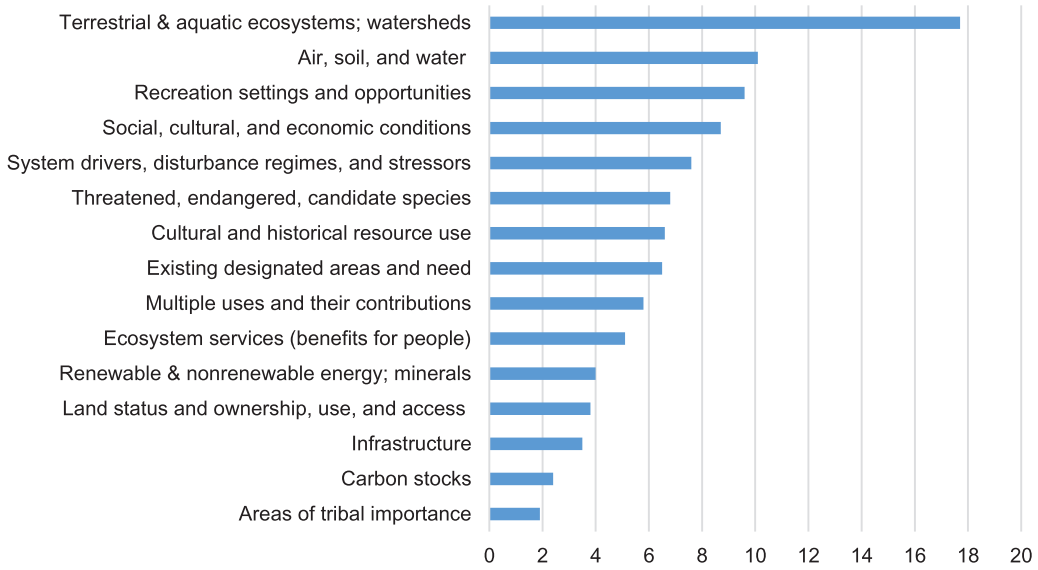

Figure 3. Average percentage of pages devoted to each topic in each forest assessment for all forests combined

have any pages that were specifically devoted to the topic, but references to the topic were instead interspersed throughout the report and it was too difficult to separate them from other topic page counts.

Two of the national forests (Inyo and Nantahala-Pisgah) published assessment reports that consisted of 15 chapters that directly reflected each of the required topics. Meanwhile, the Chugach and Cibola took a different approach; some of the chapter topics aligned with the topic requirements in the 2012 rule, but other required topics were broken up and distributed among multiple chapters. For example, the Chugach had one chapter for areas of tribal importance and one chapter for land status and ownership, but divided the terrestrial and aquatic ecosystems and watersheds

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Table 5. Percent allocation of predominant topics among four forest assessments.

Rank	Chugach topics	Pct.	Cibola topics	Pct.	Inyo topics	Pct.	N&P topics	Pct.
1	Terrestrial and aquatic ecosystems	23%	Air, soil, and water	19%	Terrestrial and aquatic ecosystems	21%	Terrestrial and aquatic ecosystems	16%
2	Benefits obtained by people (ecosystem services)	17%	Social, cultural, and economic conditions	16%	Threatened and endangered species	13%	Cultural and historic resources	12%
3	System drivers, disturbance regimes, and stressors	14%	Terrestrial and aquatic ecosystems	11%	Recreation settings and opportunities	9%	Recreation settings and opportunities	11%
4	Recreation settings and opportunities	10%	Cultural and historic resources	9%	System drivers, disturbance regimes, and stressors	8%	Air, soil and water	10%
5	Social, cultural, and economic conditions	7%	Recreation settings and opportunities	9%	Multiple uses	8%	Multiple uses	9%
Total		71%		63%		59%		59%

into five chapters, one each for watersheds, fish, wetlands, vegetation, and wildlife, and these chapters were integrated with material discussing soils and carbon stocks. Two forests did not have any pages specifically devoted to one required topic each (benefits obtained by people for the Cibola, and multiple uses for the Chugach), but these subjects were still referenced in the context of the other topics.

For all four assessments combined, the required topic with the largest average percentage of pages was terrestrial and aquatic ecosystems and watersheds (17.7%), followed by air, soil, and water resources (10.1%) and recreation opportunities (9.6%) (Figure 3).

Terrestrial and aquatic ecosystems and watersheds comprised the largest section of the assessment for three of the four forests. Air, soil, and water was especially prominent for the Cibola National Forest, and all of the forest assessments covered recreation evenly. In contrast, the three required topics with the smallest page counts, on average, were areas of tribal importance (1.9%), carbon stocks (2.4%), and infrastructure (3.4%). Benefits obtained by people (ecosystem services) had the most variable coverage, with one of the shortest sections for three of the four forest assessments, but the second longest topic for the Chugach National Forest. In all four assessment documents, benefits obtained by people were mentioned throughout the document in sentences or paragraphs at too fine a scale for this analysis to count.

We found some variation among the forest assessments in terms of the extent to which a forest focused on a particular topic (Table 5).

For the Chugach National Forest, the top five topics comprised more than 70% of the assessment, with the bulk emphasizing terrestrial and aquatic ecosystems, which reflects the importance of salmon habitat. The Chugach was the only forest to emphasize ecosystem services as a predominant framework to capture benefits obtained by people. However, other forests may have captured this topic under the category of multiple uses. Disturbance regimes (fire and invasive species) were also important for the Chugach. The Cibola National Forest was unique in their emphasis on air, soil, and water as well as social, cultural, and economic conditions and cultural and historic sites. Because water access is very important in the southwest, the predominance of this topic is not surprising. For the Inyo National Forest, the topic of threatened and endangered species was prominent, while topics related to recreation and disturbance regimes (fire, invasive species, and other ecosystem stressors) were also important. Meanwhile, cultural and historical resources were prominent in the Nantahala and Pisgah National Forests, along with recreation.

Although the 2012 rule provides a list of 15 distinct required topics, these topics overlap and are not discussed in complete isolation from one another. As we found in our analysis, it is difficult to discuss multiple uses without also discussing benefits obtained by people; air, soil, and water resources; recreation; and terrestrial and aquatic ecosystems and watersheds. In our analysis, we often found that an assessment chapter devoted to a required topic also contained information that closely resembled material discussed elsewhere. In particular, we found the chapters on multiple uses and benefits obtained by people to be largely redundant, given the other topics that were also included in the report.

Sources and types of information in the forest assessment

To understand the sources and types of information used in the assessments, we conducted a systematic examination and tally of citations by publication source and type. Overall, government sources were the most commonly cited information source (51.8%), followed by scientific scholarly publications (30.7%) (Table 6).

Table 6. Citations based on information source for forest assessments.

	Count (Percent)				
Publishing entity	**Chugach**	**Cibola**	**Inyo**	**Nantahala & Pisgah**	**TOTAL (Mean)**
Government	239 (53.6%)	159 (49.8%)	131 (49.8%)	109 (54.0%)	**638 (51.8%)**
Scientific scholarly or peer reviewed	155 (34.8%)	82 (25.7%)	82 (31.2%)	63 (31.2%)	**382 (30.7%)**
Non-government	21 (4.7%)	39 (12.2%)	24 (9.1%)	18 (8.9%)	**102 (8.7%)**
Universities	30 (6.7%)	39 (12.2%)	19 (7.2%)	11 (5.5%)	**99 (7.9%)**
Unknown or other	1 (0.2%)	0 (0%)	7 (2.7%)	1 (0.5%)	**9 (0.9%)**
TOTAL	446	319	263	202	**1230**

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Table 7. Citations based on document type for forest assessments.

Document type	Count (Percent)				
	Chugach	Cibola	Inyo	Nantahala & Pisgah	**TOTAL**
Technical report	174 (39.0%)	121 (37.9%)	108 (41.1%)	73 (36.1%)	**476 (38.5%)**
Scientific journal article	129 (28.9%)	47 (14.7%)	63 (24.0%)	48 (23.8%)	**287 (22.8%)**
Academic book	28 (6.3%)	36 (11.3%)	20 (7.6%)	15 (7.4%)	**99 (8.2%)**
Statute, regulation, or planning document	43 (9.6%)	26 (8.2%)	23 (8.8%)	12 (5.9%)	**104 (8.1%)**
Website	33 (7.4%)	42 (13.2%)	3 (1.1%)	13 (6.4%)	**91 (7.0%)**
Database	17 (3.8%)	25 (7.8%)	17 (6.5%)	18 (8.9%)	**77 (6.8%)**
Conference proceeding	10 (2.2%)	3 (0.9%)	6 (2.3%)	18 (8.9%)	**37 (3.6%)**
Non-academic book	4 (0.9%)	9 (2.8%)	10 (3.8%)	0 (0.0%)	**23 (1.9%)**
Correspondence	0 (0.0%)	7 (2.2%)	5 (1.9%)	4 (2.0%)	**16 (1.5%)**
Thesis or dissertation	8 (1.8%)	2 (0.6%)	2 (0.8%)	1 (0.5%)	**13 (0.9%)**
News	0 (0.0%)	1 (0.3%)	3 (1.1%)	0 (0.0%)	**4 (0.4%)**
Unknown	0 (0.0%)	0 (0.0%)	3 (1.1%)	0 (0.0%)	**3 (0.3%)**
TOTAL	446 (100.0%)	319 (100.0%)	263 (100.0%)	202 (100.0%)	**1230 (100.0%)**

A large portion of the government sources included US Forest Service publications (average of 28%), which were more commonly cited than other federal government sources (average of 12%) or state and local governments (average of 11%). Some variation exists among the forests in our sample, but the trends were consistent in terms of reliance on government sources and scholarly peer-reviewed publishers for the majority of citations (82.5% combined average for both categories). The Chugach relied to a greater degree on scholarly publications than other forests. The Cibola had the highest proportion from non-governmental organizations and trade groups (12.2%). The Inyo and the Nantahala and Pisgah mirrored the group average.

Next, we explored citations by the type of document referenced. We found that technical reports were the most common type of document cited in the assessments, with an average of 38.5% (Table 7).

The technical report classification is broad and includes technical and scientific reports, policy briefings, white papers, and other types of information (sometimes referred to as gray literature). All four forests were consistent in the ratio of technical reports cited. The second most common document type was the scientific journal article, with an average of 23%, although the Cibola assessment featured far fewer than the other forests. All of the forests cited a wide variety of regulations, statutes, and planning documents, (e.g., water quality regulations, county comprehensive plans, environmental impact statements, state resource management plans, and forest plans). The Cibola assessment featured the greatest variety of document types, relying on websites and academic books more than the other forests. The Nantahala and Pisgah assessment relied more heavily on conference proceedings. The least commonly cited document types, on average, were news articles (0.4%), theses or dissertations (0.9%), and correspondence (1.5%). Although there is a separate category for websites, documents in many of the other categories were readily available online.

Table 8. Approaches to identifying and using BASI from interview data.

BASI approach	Chugach	Nantahala/ Pisgah	Inyo
Literature review (e.g. Google Scholar for scholarly literature)	x	x	x
Forest Service reports, monitoring data	x	x	x
Personal expertise/training/judgement	x	x	x
Existing dataset/database	x		x
Nearby Forest Service research station		x	x
Nearby university		x	
Host data sharing meeting (partners and stakeholders)		x	
Meet with scientists		x	
Post draft documents on wiki site for public review/editing			x
Other public review opportunity		x	
Gray ("non-peer-reviewed") literature, traditional knowledge			x

Identifying and using best available scientific information in the forest assessment

In interviews, respondents were asked how they identified and obtained BASI for their assessment. Table 8 displays the different approaches used by three of the four forests.

Literature reviews and searches, Forest Service reports and datasets, and personal scientific expertise were mentioned by all nine respondents as primary ways that they identified and obtained BASI. Literature reviews focused on identifying peer-reviewed journals, conference proceedings, or agency reports. Existing datasets and nearby Forest Service research stations and universities were also relied upon. The Sierra Nevada science synthesis effort, which informed the Inyo National Forest assessment, took nearly 18 months to complete (Long et al. 2014). The Inyo also posted draft documents on a wiki site for public review and editing. All nine interviewees stated that their assessment team used the Draft Planning Directives, but also mentioned that the directives were not clear, save for the focus on organizing around the 15 topics. No respondent mentioned specific guidance beyond the draft directives on how to identify BASI. The final directives do specifically address the definition of BASI, as discussed above (Figure 2). Gray literature and traditional knowledge presented challenges, as it at times conflicted with peer-reviewed information. Two respondents mentioned that they wanted to incorporate this type of information, but were unsure how to do so.

Assessments must document what information was determined to be BASI, explain the basis for that determination, and explain how the information was applied to the issues considered (36 CFR

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219.3). Our analysis of the assessment documents reveals that all documents discuss the use of high-quality and valid scientific information, citing criteria such as clearly defined and well-developed methodology; standardized methodology; logical conclusions; and reasonable inferences (Chugach National Forest 2014; Inyo National Forest 2014; Nantahala and Pisgah National Forests 2014; Cibola National Forest and National Grasslands 2015). The assessments for all forests mention their reliance on information relevant to their specific forests and issues. Only the Nantahala-Pisgah assessment presented a hierarchy of information sources, with peer-reviewed journal articles the highest, followed by government documents and reports, monitoring datasets, theses and dissertations from universities, and expert opinion where facts were not known through the other sources.

Discussion

The 2012 forest planning rule requires that each national forest or grassland conduct a scientific assessment to guide plan development. We found that assessment reports were disproportionately heavy in science related to terrestrial and aquatic ecosystems, and more limited in treatment of infrastructure, land ownership and access patterns, cultural heritage, and areas of tribal importance. Recreation was the only topic to receive consistent attention across all four forests, although the topic was overshadowed by terrestrial and aquatic ecosystems. We may only speculate about why terrestrial and aquatic ecosystem information was the most prevalent in all four forests, but it is consistent with agency administrative hiring practices since the 1980s that have emphasized recruitment of ecologists, biologists, and other biophysical scientists, compared to social scientists, for example (Thomas and Mohai 1995). The abundance of agency specialists in these topic areas may reinforce the relative importance of terrestrial and aquatic ecosystems compared to other topic areas, such as recreation, social science, or cultural resource management. This has been confirmed by a national assessment of interdisciplinary planning team composition (Cerveny et al. 2011). Ensuring that assessment teams include broad and diverse disciplinary experts will help address this challenge, recognizing that some forests may not have access to necessary disciplinary specialists. It is also possible that some of the topics (e.g., ecosystem services, tribal and cultural resources, land status and use patterns) simply do not have as much relevant and available information as other topics.

The benefits obtained by people (ecosystem services) topic received little or no explicit coverage in all but one assessment. The limited coverage of ecosystem services may make sense because it was not even considered an area of research until the late 1990s, so there would be less existing information on certain important ecosystem service topics (e.g., pollination, stormwater attenuation, medicinal resources, and spiritual and historical significance) compared to recreation, threatened and endangered species, and other traditional assessment topics (Blahna et al. 2017). Previously, "forest benefits to people" were considered elements of "multiple use" and planners might have addressed these benefits under the "multiple use" topic. Ecosystem services (ES) are often categorized into four classes: provisioning, regulating, cultural, and supporting. Timber, recreation, wildlife, and other traditional forest planning topics all fall into one of these four classes. Another reason for lack of coverage of ecosystem services may be that planners could not differentiate the normal assessment topics from the ecosystem service classes. Efforts to help planning team members understand ecosystem services approaches and how they can be used to inform the planning process may be warranted, and the rule's current requirement for only using existing data in assessments may need to be revisited (Blahna et al. 2017). For example, implementation teams working on ecosystem services may consider the benefits of providing specific tools, frameworks, and guidelines for integrating ecosystem services models into the forest planning process. In addition, critical issues and topics (e.g., newly listed threatened or endangered species, or changing recreation behaviors) that forest plans need to address may change from one planning cycle to the next.

The specific required topics may not be universally appropriate for every planning unit. Planners felt obligated to address all 15 topics, but the lack of coverage for some topics suggests that the topic was not deemed relevant or meaningful for their plan, there was no available data on the topic, or it was unclear how the topics could be covered. Variability in application of the directives, and acknowledgment of local context and conditions, is consistent with the overall Forest Service approach toward decentralized decision-making (Kaufman 1960; Tipple and Wellman 1991; Koontz 2007) and localized interpretation by planning teams, similar to "street-level" bureaucrats who create de facto policy through everyday practice (Sabatier et al. 1995; Lipsky 2010; Trusty and Cerveny 2012). Kaufman (1960) observes the traditional Forest Service practice of maintaining control of heterogeneous and geographically dispersed management units by issuing centralized directives that provide parameters (or "side boards") within which line officers have some leeway to make decisions. This tendency toward uniformity and "pre-formed" decisions may result in some inefficiencies and omissions. The implied obligation to cover all 15 topics may have resulted in some assessments that distract from the most important management issues for the unit. This will be especially important during the next stage of planning—revision or amendment—where the assessment data will be used to analyze different management scenarios. Approaches for identifying and analyzing the most relevant assessment data that address the key environmental problems or social conflicts that confront each planning unit will be needed (Blahna et al. 2017). This is especially important for topics like human benefits (ecosystem services) and multiple uses, which cut across all of the other topical areas and are not as easily categorized in assessments. Recent efforts to engage the public in science synthesis efforts in support of forest planning suggest that there may be an important role for the public to help prioritize forest assessment topics.

The most common sources of information were government sources, followed by scholarly academic sources. Many of the agency sources were peer-reviewed scientific studies, which appear to be especially useful because of the topical specificity or geographic focus (relevance). Although not all technical reports are peer reviewed, they may be more accessible and usable compared to scholarly journal articles, which may require planning team members to interpret the findings and make inferences for relevance to local conditions. This finding is consistent with previous research examining the information needs and sources of Forest Service fire managers (Ryan and Cerveny 2011) and recreation managers (Ryan and Cerveny 2010). Fire managers relied heavily on agency information sources. Although managers in the study noted the availability of high-quality, relevant information, they faced significant barriers in terms of time, funding,

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and personnel to access and use that information. Similarly, recreation managers also relied on agency information sources, but indicated strong preferences for enhanced interactions with agency scientists, including collaborative research, conferences, and a desire for agency researchers to reach out more directly to managers to ensure their research was relevant and useful. With regard to forest assessments, engagement with scientists is particularly important for topics where little research is available. Assessment teams may want to consider additional ways to interact with scientists and others to create functioning communities of practice related to science exchange for forest planning. In the same way, agency scientists may consider forging new and enduring relationships with planners and managers that could generate new science that is of immediate relevance.

The 2012 planning rule and its directives provide criteria for BASI, and we found similarities across all forests in the most common approaches to identifying BASI, in addition to other approaches, such as data sharing meetings, a wiki review site, and requests for a science synthesis. Information from non-peer-reviewed sources was more difficult for planners to assess and evaluate, and it is not clear how this information was incorporated into each assessment. Teams may not have the capacity to separately evaluate and assess the many different types and sources of information, and so they rely on hierarchical ranking approaches (peer-reviewed sources being highest rank) to streamline the evaluation. Planning teams clearly value peer-reviewed and agency-generated information, and it may be that they are simply identifying information that is "available" and using the "best" of that based on their judgments. This may result in situations where the science expertise on each team could influence BASI decisions. As discussed above, consideration of the makeup and membership of the assessment team is important here, as well as increased transparency regarding the process for determining science relevance and quality.

Conclusion

Implementation of the US Forest Service 2012 planning rule is still in its early stages. Our study illustrates that forest planners use a variety of approaches to address required topics, and do rely on BASI as they develop their forest assessments. While each national forest assessment included the 15 required topics, we found considerable variation in coverage, which suggests that planners may emphasize topics most relevant to their forest, or that variation exists in terms of what science or planning team expertise is available or deemed desirable. The predominance of science related to terrestrial and aquatic ecosystems in the assessments compared to other topics warrants further inquiry in order to learn whether this asymmetry is based on policy, availability of information, existing expertise, or other factors. Efforts to include the public in the process of prioritizing topics for the assessments could also be evaluated. The reliance on government sources for scientific information suggests that agency-supported science is either more accessible or more relevant to the planning team. It also suggests that there may be benefits to bolstering "communities of practice" for key topical areas covered by forest assessments that bring together university and agency scientists with managers.

The appearance of science in an assessment report is important, but the actual *use* of science in planning may be more important. Although our findings are not generalizable to all national forests, they do provide an understanding of plan assessment activities for those in the early phases of forest planning, whose efforts are likely to inform and influence other national forests. Our goal was to provide an early glimpse of plan revision efforts in order to highlight important lessons learned and create a foundation for future research. For example, do planners find that the required topics provide useful guidance for developing their assessments? How can planners become more confident in knowing what BASI is, and how to identify and use it? Is additional guidance needed for incorporation of traditional knowledge and other information? Of particular interest is whether the "science synthesis" information is useful to forest planners in addressing their forest assessment needs, given the significant agency resources devoted to developing science syntheses. Finally, how is information from the assessment used in forest plan revision (development and selection of management options) and monitoring efforts? While draft environmental impact assessment (EIS) reports are available in various stages, as of this writing only one final Record of Decision (ROD) has been issued for a forest plan undergoing revision under the 2012 rule. Thus, it remains to be seen how scientific information will be incorporated in development of alternatives, impact statements, and final management decisions.

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ORIGINAL RESEARCH

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Living on the edge: Exploring the role of coastal refugia in the Alexander Archipelago of Alaska

Yadéeh E. Sawyer[1] | Stephen O. MacDonald[1] | Enrique P. Lessa[2] | Joseph A. Cook[1]

[1]Department of Biology and Museum of Southwestern Biology, University of New Mexico, Albuquerque, New Mexico

[2]Departamento de Ecología y Evolución, Facultad de Ciencias, Universidad de la República, Montevideo, Uruguay

Correspondence
Yadéeh E. Sawyer, Department of Biology and Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM.
Email: yadeehsawyer@gmail.com

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Abstract

Although islands are of long-standing interest to biologists, only a handful of studies have investigated the role of climatic history in shaping evolutionary diversification in high-latitude archipelagos. In this study of the Alexander Archipelago (AA) of Southeast Alaska, we address the impact of glacial cycles on geographic genetic structure for three mammals co-distributed along the North Pacific Coast. We examined variation in mitochondrial and nuclear loci for long-tailed voles (*Microtus longicaudus*), northwestern deermice (*Peromyscus keeni*), and dusky shrews (*Sorex monticola*), and then tested hypotheses derived from Species Distribution Models, reconstructions of paleoshorelines, and island area and isolation. In all three species, we identified paleoendemic clades that likely originated in coastal refugia, a finding consistent with other paleoendemic lineages identified in the region such as ermine. Although there is spatial concordance at the regional level for endemism, finer scale spatial and temporal patterns are less clearly defined. Demographic expansion across the region for these distinctive clades is also evident and highlights the dynamic history of Late Quaternary contraction and expansion that characterizes high-latitude species.

KEYWORDS

Coastal Refugia Hypothesis, comparative phylogeography, endemism, islands, small mammals

1 | INTRODUCTION

Varying isolation, area, and topography make islands of long-standing interest to studies in evolution, ecology, and conservation biology (Berry, 1986; Fattorini, 2009). Limited connectivity between islands lowers genetic exchange, leading to divergent populations and increased endemism (Adler, 1992; Dobzhansky, 1963; Whittaker, 1998). Because many insular biomes remain understudied, endemism is often poorly documented, yet island biotas likely contribute to global biodiversity more than currently appreciated (Bickford et al., 2007). Tropical oceanic islands have provided key insights into our understanding of diversity, especially in relation to how island area and isolation may shape species richness, community assembly, and patterns of diversification (e.g., Gifford & Larson, 2008; Gillespie, Claridge, & Goodacre, 2008; Hamilton, 1963). But even in tropical island systems, understanding of island composition and genetic relationships is more complex than originally assumed (Filardi & Moyle, 2005). Recently, the various impacts of dynamic geologic events of the Quaternary (2.6 Ma – present), such as changes in sea level, are receiving closer scrutiny in lower latitude archipelagos (e.g., Esselstyn, Timm, & Brown, 2009; Heaney, Walsh, & Peterson, 2005) and along coastal ecosystems (Dolby, Ellingson, Findley, & Jacobs, 2018). Relatively few comparative studies (e.g., Pedreschi, Kelly-Quinn, Caffrey, O'Grady, & Mariani, 2014; Sota & Nagata, 2008), however, have explicitly investigated the role of climatic history in evolutionary diversification in high-latitude

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coastal archipelagos, where dynamic glacial advances potentially restructured entire communities repeatedly.

During the Last Glacial Maximum (LGM; between 26.5 and 19 kya), ice covered much of North America (Figure 1; Dyke & Prest, 1987; Mandryk, Josenhans, Fedje, & Mathewes, 2001), restricting species distributions to ice-free regions in the north (e.g., Beringia), south (continental), or along the coasts (Marr, Allen, & Hebda, 2008). As the Laurentide and Cordilleran ice sheets receded, periglacial populations recolonized previously ice-covered regions (Eddingsaas, Jacobsen, Lessa, & Cook, 2004; Lessa, Cook, & Patton, 2003) throughout North America. Colonization and extinction dynamics of the land bridge islands along the northwest coast of North America are thought to more closely resemble those of oceanic islands (Conroy, Demboski, & Cook, 1999; Whittaker & Fernández-Palacios, 2007) because glacial cover from the Cordilleran Ice Sheet hypothetically created a clean slate down to tidewater (Klein, 1965). Areas previously glaciated were presumably colonized from multiple ice-free (Beringian, southern continental) regions during the late Pleistocene-early Holocene (14 to 10 kya), with independent recolonization from disparate sources hypothesized to have shaped the contemporary genetic structure of coastal biota. Due to eustatic and isostatic fluxes at the LGM, the Alexander Archipelago (AA) of Alaska and Haida Gwaii of British Columbia experienced sea levels up to 165 m lower (Baichtal, Carlson, & Crockford, 2008; Hetherington et al., 2003; Shugar et al, 2014); however, there remains substantial uncertainty regarding the extent of glaciation in this region (Buma et al., 2013; Carrara, Ager, & Baichtal, 2007; Carrara, Ager, Baichtal, & VanSistine, 2003; Elias, 2013; Fladmark, 1979). The earliest initiation of deglaciation in the region is now estimated at about 17,000 ybp (Lesnek, Briner, Lindqvist, Baichtal, & Heaton, 2018). Although many of the islands were buried under 1,000 m of ice, coastal refugia may have persisted along the exposed western continental shelf (e.g., Baichtal & Carlson, 2010; Fladmark, 1979). This Coastal Refugia Hypothesis remains poorly documented, however, and hinges on whether species persisted and diverged in isolation through the LGM, thereby becoming significant source

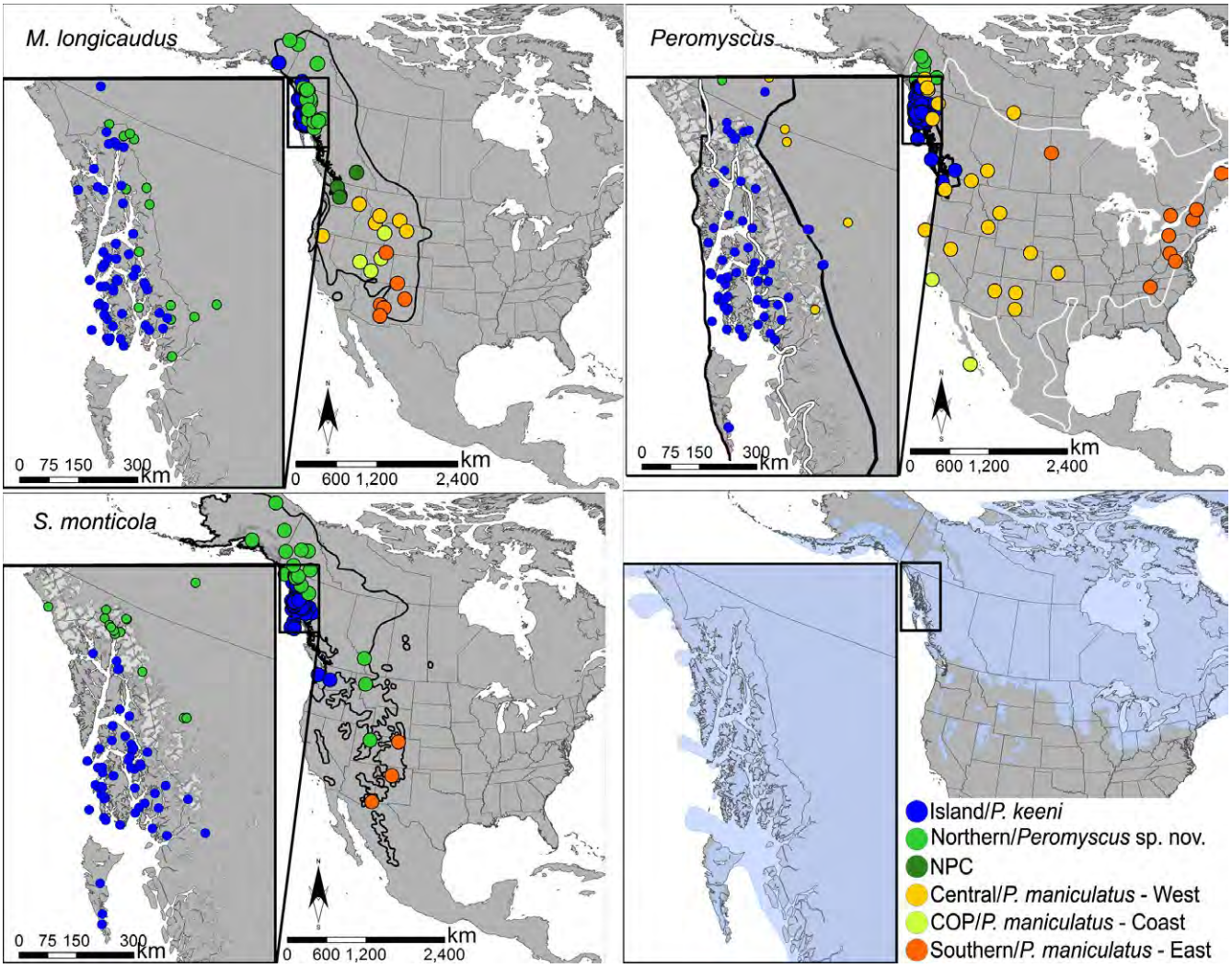

FIGURE 1 Sampling scheme, range maps, and North American LGM glacial cover. Sampling localities are shown by major cyt*b* lineage. The thick black lines are the current range for each species, with the addition of *P. maniculatus* (white line) on the *Peromyscus* map. The light blue in the bottom right image is LGM glacial ice cover. COP: Colorado Plateau; LGM: Last Glacial Maximum; NPC: North Pacific Coast. Color schemes for species and lineages are held constant across figures

populations for recolonization of deglaciated island and continental areas in northwestern North America (Byun, Koop, & Reimchen, 1999, 1997; Demboski, Stone, & Cook, 1999).

As glaciers receded and sea levels rose, the islands of the AA became increasingly fragmented, although the sequence of fragmentation is complex due to isostatic rebound (Carrara et al., 2007). Subsequent in situ diversification across the AA hypothetically produced endemic populations due to either long-term occupation of the region (paleoendemics that originated from coastal refugia) or recent colonization from sources outside the region (neoendemic; Cook, Dawson, & MacDonald, 2006; Cook & MacDonald, 2013). Long-term field studies (Cook et al., 2017; MacDonald & Cook, 2007) have now produced the density of sampling across the archipelago necessary to begin to explore this complexity for mammals.

The AA is one of the planet's most extensive archipelagos with >1,100 named islands including 7 of the 15 largest United States islands. Together with Haida Gwaii to the south, these archipelagos support a significant portion of the remaining coastal temperate rainforest worldwide (DellaSala et al., 2011; Ecotrust & Conservation International, 1992). Most of the islands within this archipelago are managed by the Tongass National Forest (6.9 million ha; United States Geological Survey, 2010) and have been heavily modified by industrial timber harvests and associated fragmentation (e.g., roads) over the past 60 years (Albert & Schoen, 2013; List, 2000; Schoen & Dovichin, 2007). The rugged and ice-laden Coast and Wrangell–St. Elias mountain ranges that border the adjacent mainland to the east and north have acted as barriers to dispersal that filtered the movement of species into and out of the region (Cook & MacDonald, 2013).

Previous regional phylogeographic studies identified divergent and endemic populations of various taxa, including a number of vascular and non-vascular plants (Brodo & Sloan, 2004; Hannon, D'Amore, Witter, & Lamb, 2010; Soltis, Gitzendanner, Strenge, & Soltis, 1997), terrestrial invertebrates (Clarke, Levin, Kavanaugh, & Reimchen, 2001), fishes (Kondzela et al., 1994; O'Reilly, Reimchen, Beech, & Strobeck, 1993; Smith, Nelson, Wood, & Koop, 2001), birds (Barry & Tallmon, 2010; Bull, McCracken, Gaston, Birt, & Friesen, 2010; de Volo, Reynolds, Sonsthagen, Talbot, & Antolin, 2013), and a series of mammals such as northern flying squirrels (*Glaucomys sabrinus*, Bidlack & Cook, 2002), red-backed voles (genus *Myodes*, Runck, Matocq, & Cook, 2009), red squirrels (*Tamiasciurus hudsonicus*, Hope et al., 2016), ermine (*Mustela erminea*, Dawson, Hope, Talbot, & Cook, 2014; Fleming & Cook, 2002), black bear (*Ursus americanus*, Peacock, Peacock, & Titus, 2007), and mountain goats (*Oreamnos americanus*, Shafer, White, Cote, & Coltman, 2011). To date, few studies in the AA have focused on co-distributed, multi-species assemblages.

Small mammals are optimal for exploration of comparative phylogeographic signatures because they are relatively abundant, widespread, and have limited vagility. We examine the role of historical climate variability in structuring contemporary genetic variation of two rodents, *Microtus longicaudus* and *Peromyscus keeni*, and a shrew, *Sorex monticola*; all are widely co-distributed throughout the AA and adjacent mainland. Previous analyses of mitochondrial DNA variation of a reduced set of localities in the region uncovered significant inter-population variation in these mammals (Conroy & Cook, 2000; Demboski & Cook, 2001; Lucid & Cook, 2004). Although these species are frequently sympatric, *M. longicaudus* (an herbivore) tends to prefer more open herbaceous habitats, *P. keeni* (an omnivore) typically occurs in forest and scrub habitats, and *S. monticola* (an insectivore) usually occupies forested and non-forested habitats with dense ground cover (Van Horne, 1981, 1982; Smith & Belk, 1996; Smolen & Keller, 1987; Zheng, Arbogast, & Kenagy, 2003). The dietary isotopic niches of these species largely do not overlap as well (O'Brien, Cook, & Newsome, 2017). If all three species expanded from shared refugia, genetic signatures tracking their expansion histories may be congruent due to the common influence of climatic events (i.e., top-down environmental control), regardless of specific ecological differences or niche requirements.

In this study, we test three related questions. First, we assess the effects of geological history and climatic conditions on phylogeographic signatures of *M. longicaudus*, *P. keeni*, and *S. monticola*, with a focus on testing the Coastal Refugium Hypothesis (Fladmark, 1979). We use species distribution models (SDMs; Figure 2) and historical bathymetric reconstructions (Figure 3) across species to identify areas of endemism and their spatiotemporal relationship to potential refugia, including coastal refugia.

Next, we test whether phylogeographic signatures are concordant across the three species. An expectation of shared history should result in signatures reflecting similar responses to climatic events and geographic barriers and corridors. Conversely, if taxa have idiosyncratic histories, we expect to observe highly distinctive phylogeographic structure.

Lastly, we integrate the niche models, bathymetry, and demographic analyses to test for concordant signatures of demographic and spatial expansion to assess whether the three species responded similarly to the warming trends of the early Holocene. Signatures of historic expansion may be expected in island populations as a result of post-glacial colonization following increased island connectivity that occurred when sea levels were lower during glacial periods.

2 | MATERIALS AND METHODS

2.1 | Sample collection and sequencing

Specimens (*n* = 137 *M. longicaudus*, 146 *P. keeni*, and 149 *S. monticola*; Supporting Information Appendix S1) were collected through fieldwork between 1991 and 2012 and archived at the University of New Mexico's Museum of Southwestern Biology (MSB) and the University of Alaska Museum of the North. Tissues were also obtained on loan from the University of Washington Burke Museum and Gwaii Haanas National Park Reserve and Haida Heritage Site (13 *P. keeni*, and 3 *S. monticola*). Sampling covered 44 localities across Southeast Alaska and Haida Gwaii. All recognized subspecies (Hall, 1981) found in or near Southeast Alaska for each species were represented. Closely related outgroup species (*n* = 3 *Microtus*, 40 *Peromyscus*, and 9 *Sorex*) were also sequenced. Additionally, we

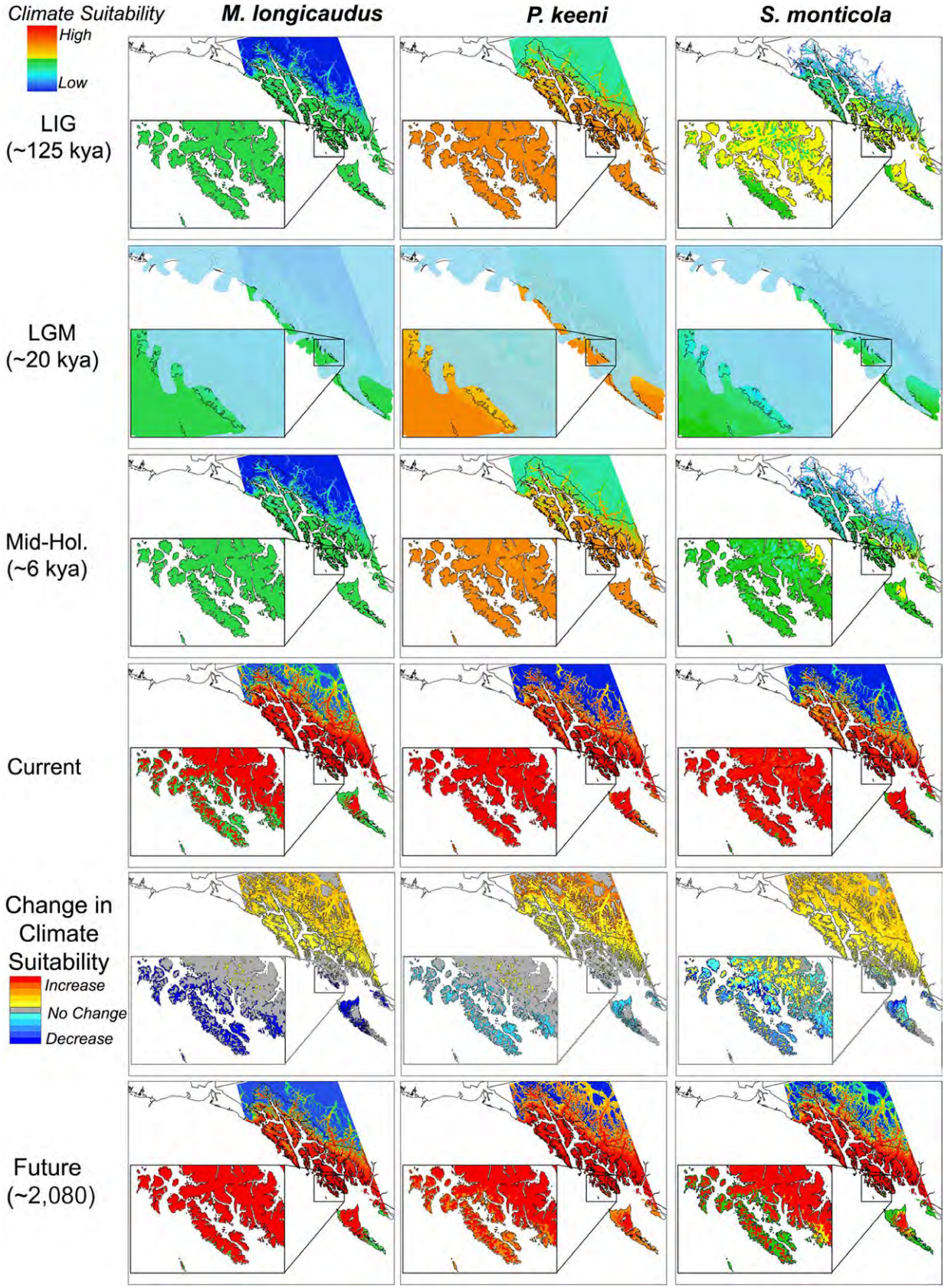

FIGURE 2 Species distribution models (climate suitability at each time period) for *Microtus longicaudus*, *Peromyscus keeni* and *Sorex monticola* from the Last Inter-Glacial (LIG), Last Glacial Maximum (LGM; solid blue = glacial ice coverage), Mid-Holocene (Mid-Hol.), Current, and Future (approximately the year 2080), including the change in habitat suitability between current and future models

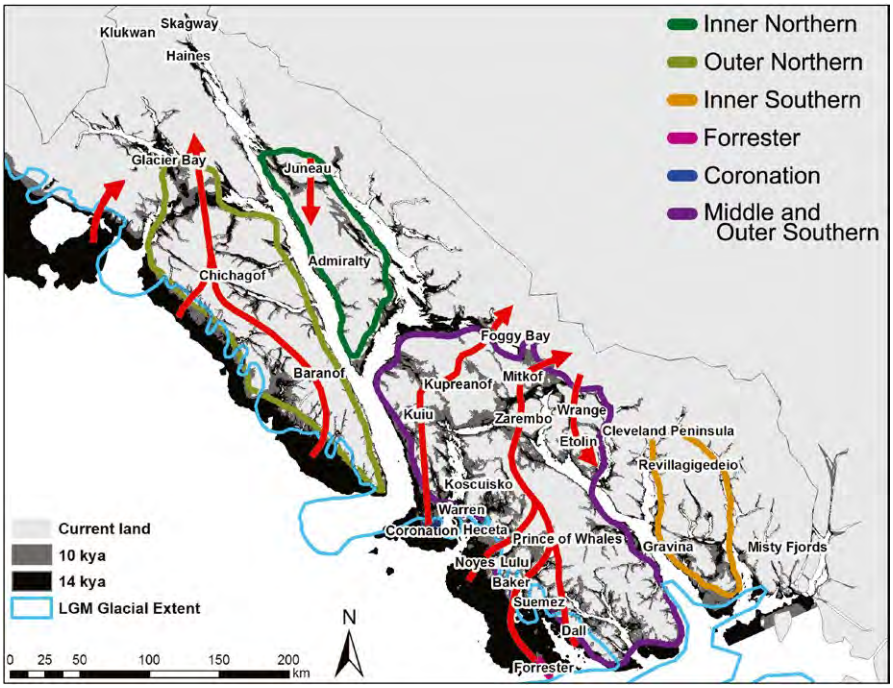

FIGURE 3 Islands and nearby coastal mainland locations in Alaska, including paleoshorelines (kya = thousands of years ago) and hypothesized island groups (also see Table 2). Red arrows indicate potential colonization across the Alexander Archipelago as a result of change in sea level and glacial cover

used GenBank sequences representing 41 *M. longicaudus*, and 18 *P. maniculatus* (Supporting Information Appendix S1).

We extracted total genomic DNA to a final concentration of 50 ng/µl using either Omega Bio-Tek (Norcross, GA) E.Z.N.A. or standard salt extraction (Fleming & Cook, 2002). Polymerase chain reactions (PCR) amplified mitochondrial (mtDNA) cytochrome *b* (cyt *b*) and three nuclear loci per genus, chosen based on variability observed in previous work and preliminary assessment within this study (*Microtus*: Protein C-est-2 (ETS2), β-fibrinogen (FGB), and Recombination Activating Protein 1 (Rag1); *Peromyscus*: β-fibrinogen (FGB), interphotoreceptor retinoid-binding protein (IRBP), and zona pellucida 3 (ZP3); *Sorex*: Alcohol Dehydrogenase 2 (ADH2), Apolipoprotein B (ApoB), and β-fibrinogen (FGB); Supporting Information Appendix S2).

Nuclear heterozygotes were inferred with PHASE v2.1 (Stephens & Scheet, 2005; Stephens, Smith, & Donnelly, 2001) using five runs with 1,000 iterations (different seeds) and a burn-in of 1,000. Iterations with the best goodness-of-fit were chosen. Posterior probabilities (PP) for nucleotides ≥0.85 were chosen; otherwise ambiguous sites were coded as N. All analyses used phased sequence data. Sequences were edited in SEQUENCHER v4.2 (GeneCodes Corporation), aligned in MEGA v5.2 (Tamura et al., 2011) using the MUSCLE algorithm and confirmed by eye.

2.2 | Testing phylogenetic models under the Coastal Refugia Hypothesis

To determine whether climatic conditions in the AA remained within species climatic thresholds, we generated SDMs for each species under current, mid-Holocene (~6 ka), LGM (~21 kya) (http://pmip2.lsce.ipsl.fr/; Braconnot et al., 2007), last inter-glacial (LIG; ~120–140 kya), and future conditions (twice the current levels of CO_2, ~2080, Christensen et al., 2007). Bioclimatic variables were obtained from WORLDCLIM (www.worldclim.org, Hijmans, Cameron, Parra, Jones, & Jarvis, 2005) at a resolution of 2.5 arc-minutes and clipped to incorporate only Southeast Alaska and the surrounding mainland. Test layers were clipped to the extent of sampling, while projection layers were for western North America. ENMTOOLS (Warren, Glor, & Turelli, 2008, 2010) was used to determine highly correlated variables (Pearson correlation coefficient ≥0.75), which we then reduced based on those most biologically relevant to small mammals (i.e., temperature related), to avoid over-parameterized models. Final runs were performed using bioclimatic variables 1 (annual mean temperature), 6 (minimum temperature of coldest month), 7 (temperature annual range), and 11 (mean temperature of coldest quarter), and run using a test percentage of 25%. We obtained species localities from museum databases (e.g., ARCTOS [http://arctos.data-base.uaf.edu] and MaNIS [http://manisnet.org/], Stein & Wieczorek, 2004) in October 2013. Sites with large spatial errors were removed and localities within <12 km of each other were eliminated (Hope et al., 2011) to reduce potential spatial autocorrelation (Reddy & Davalos, 2003), resulting in 127 *M. longicaudus*, 150 *P. keeni*, and 145 *S. monticola* sample localities. SDMs for each species were constructed at each time period using MAXENT v3.3.3k (Elith et al., 2006; Phillips, Anderson, & Schapire, 2006; Phillips & Dudik, 2008). Final runs were performed using cross-validation across 10 replicates, with a regularization parameter of 5 (Hope et al., 2011; Warren & Seifert, 2011) and 1,000 iterations. All other values

TABLE 1 Locality information, abbreviations, and island-specific demographics

Region	Location	Refugia	Hypothesized island group	*M. longicaudus*						
				n	*S*	*h*	*Hd*	π	F_{ST} (mean)	◊
Alaskan Islands	Admiralty (ADM)*	no	Inner Northern	–	–	–	–	–	–	
	Baker (BKR)*	no	Middle and Outer Southern	–	–	–	–	–	–	
	Baranof (BNF)	no	Outer Northern	–	–	–	–	–	–	
	Chichagof (CGF)*	yes	Outer Northern	5	6	5	1.0000	0.0023	0.2430	
	Coronation (CRN)*	yes	Coronation	4	4	2	0.5000	0.0018	0.3700	◊
	Dall (DAL)*	yes	Middle and Outer Southern	5	9	5	1.0000	0.0033	0.1470	◊
	Etolin (ETN)*	no	Middle and Outer Southern	–	–	–	–	–	–	
	Forrester (FRS)*	yes	Forrester	4	2	2	0.6670	0.0013	0.3960	◊
	Gravina (GRV)*	no	Inner Southern	–	–	–	–	–	–	
	Heceta (HEC)*	no	Middle and Outer Southern	–	–	–	–	–	–	
	Kosciusko (KSC)*	no	Middle and Outer Southern	5	8	4	0.9000	0.0030	0.2080	
	Kuiu (KUI)*	no	Middle and Outer Southern	5	18	5	1.0000	0.0067	0.1600	◊
	Kupreanof (KRF)*	no	Middle and Outer Southern	4	6	3	0.8330	0.0028	0.1950	◊
	Lulu (LUL)*	yes	Middle and Outer Southern	4	0	1	0.0000	0.0000	0.1890	◊
	Mary (MRY)	no	–	–	–	–	–	–	–	
	Mitkof (MIT)*	no	Middle and Outer Southern	–	–	–	–	–	–	
	Noyes (NYS)*	yes	Middle and Outer Southern	3	1	2	0.6670	0.0006	0.1510	◊
	Orr (ORI)	–	–	–	–	–	–	–	–	
	Prince of Wales (POW)*	no	Middle and Outer Southern	6	13	6	1.0000	0.0056	0.1180	◊
	Revillagigedio (REV)*	no	Inner Southern	6	4	4	0.8000	0.0014	0.1730	◊
	San Fernando (SNF)*	no	Middle and Outer Southern	–	–	–	–	–	–	
	Suemez (SMZ)*	yes	Middle and Outer Southern	5	7	4	0.9000	0.0025	0.1360	◊
	Sukkwan (SWN)	–	–	–	–	–	–	–	–	
	Tuxekan (TXN)	no	–	–	–	–	–	–	–	◊
	Warren (WRN)	yes	Middle and Outer Southern	6	1	2	0.3330	0.0003	0.2290	
	Wrangell (WRG)*	no	Middle and Outer Southern	3	3	3	1.0000	0.0018	0.3130	◊
	Zarembo (ZRB)*	no	Middle and Outer Southern	2	4	2	1.0000	0.0035	0.1980	◊
British Columbian Islands	Bischof (BSF)	–	–	–	–	–	–	–	–	–
	Graham (GRM)	–	–	–	–	–	–	–	–	–
	Hotsprings (HTS)	–	–	–	–	–	–	–	–	–

(Continues)

TABLE 1 (Continued)

Region	Location	Refugia	Hypothesized island group	*M. longicaudus*						
				n	*S*	*h*	*Hd*	π	F_{ST} (mean)	◊
	Moresby (MRB)	–	–	–	–	–	–	–	–	–
	Ramsay (RMS)	–	–	–	–	–	–	–	–	–
	Vancouver (VCR)	–	–	–	–	–	–	–	–	–
Mainland	British Columbia (BC)	no	–	–	–	–	–	–	–	
	Mainland Southeast Alaska (MLSE)	no	–	5	11	5	1.0000	0.0051	0.0735	
	Northern mainalnd Southeast (NMLSE)	no	–	7	14	7	1.0000	0.0053	0.0351	
	Interior Alaska, Yukon and White Pass (North)	no	–	3	9	3	1.0000	0.0058	0.0320	
	Cleveland Peninsula (CP/MLCP)*	–	Inner Southern	–	–	–	–	–	–	
	Foggy Bay (FB/MLFB)*	–	Middle and Outer Southern	–	–	–	–	–	–	
	Glacier Bay (GB/MLGB)*	–	Outer Northern	–	–	–	–	–	–	◊
	Haines (HNS/MLHNS)*	–	–	–	–	–	–	–	–	◊
	Interior Alaska (IAK/MLS)	–	–	–	–	–	–	–	–	
	Juneau (JNO/MLJNO)*	–	Inner Northern	–	–	–	–	–	–	◊
	Klukwan (KLU/MLKLU)	–	–	–	–	–	–	–	–	
	Misty Fjords (MFD/MLMFD)*	–	Inner Southern	–	–	–	–	–	–	◊
	Southeast Central (SEC AK/MLSEC)*	–	–	–	–	–	–	–	–	
	Southeast North (SEN AK/MLSEN)	–	–	–	–	–	–	–	–	
	Southeast South (SES AK/MLSES)	–	–	–	–	–	–	–	–	
	Skagway (SKW/MLSKW)	–	–	–	–	–	–	–	–	
	Taiya River (TYR/MLTYR)	–	–	–	–	–	–	–	–	
	White Pass (WP/MLWP)	–	–	–	–	–	–	–	–	
	British Columbia - Central (BCC)*	–	–	–	–	–	–	–	–	
	British Columbia - North (BCN)	–	–	–	–	–	–	–	–	
	British Columbia - South (BCS)	–	–	–	–	–	–	–	–	
	Washington (WA)	–	–	–	–	–	–	–	–	
	Yukon Territory - Central (YTC)	–	–	–	–	–	–	–	–	
	Yukon Territory - South (YTS)*	–	–	–	–	–	–	–	–	◊
Region	**Location**	**Refugia**	**Hypothesized island group**	***P. keeni***						
				n	*S*	*h*	*Hd*	π	F_{ST} (mean)	◊
Alaskan Islands	Admiralty (ADM)*	no	Inner Northern	4	8	3	0.8330	0.0035	0.1200	

(Continues)

TABLE 1 (Continued)

Region	Location	Refugia	Hypothesized island group	*P. keeni*						
				n	*S*	*h*	*Hd*	π	F_{ST} (mean)	◊
	Baker (BKR)*	no	Middle and Outer Southern	3	5	3	1.0000	0.0029	0.1810	
	Baranof (BNF)	no	Outer Northern	5	4	3	0.7000	0.0014	0.1140	◊
	Chichagof (CGF)*	yes	Outer Northern	4	9	4	1.0000	0.0046	0.1330	◊
	Coronation (CRN)*	yes	Coronation	3	8	3	1.0000	0.0047	0.1760	◊
	Dall (DAL)*	yes	Middle and Outer Southern	6	11	5	0.9330	0.0041	0.1540	◊
	Etolin (ETN)*	no	Middle and Outer Southern	5	4	3	0.7000	0.0017	0.1260	
	Forrester (FRS)*	yes	Forrester	5	3	4	0.9000	0.0011	0.3580	◊
	Gravina (GRV)*	no	Inner Southern	5	2	3	0.7000	0.0007	0.2490	◊
	Heceta (HEC)*	no	Middle and Outer Southern	5	3	3	0.7000	0.0011	0.3040	◊
	Kosciusko (KSC)*	no	Middle and Outer Southern	3	4	2	0.6670	0.0023	0.2990	◊
	Kuiu (KUI)*	no	Middle and Outer Southern	3	6	3	1.0000	0.0035	0.1390	◊
	Kupreanof (KRF)*	no	Middle and Outer Southern	3	3	3	1.0000	0.0017	0.1010	
	Lulu (LUL)*	yes	Middle and Outer Southern	5	3	3	0.7000	0.0012	0.3050	◊
	Mary (MRY)	no	–	2	0	4	1.0000	0.0000	0.4170	◊
	Mitkof (MIT)*	no	Middle and Outer Southern	4	12	4	1.0000	0.0054	0.1000	
	Noyes (NYS)*	yes	Middle and Outer Southern	5	12	5	1.0000	0.0051	0.1650	◊
	Orr (ORI)	–	–	–	–	–	–	–	–	
	Prince of Wales (POW)*	no	Middle and Outer Southern	6	19	6	1.0000	0.0070	0.0692	◊
	Revillagigedio (REV)*	no	Inner Southern	5	20	4	0.9000	0.0076	0.0935	◊
	San Fernando (SNF)*	no	Middle and Outer Southern	4	12	3	0.8330	0.0053	0.2470	◊
	Suemez (SMZ)*	no	Middle and Outer Southern	3	9	3	1.0000	0.0053	0.3510	
	Sukkwan (SWN)	no	–	–	–	–	–	–	–	
	Tuxekan (TXN)	no	–	–	–	–	–	–	–	
	Warren (WRN)	no	Middle and Outer Southern	3	0	1	0.0000	0.0000	0.2620	◊
	Wrangell (WRG)*	no	Middle and Outer Southern	3	6	3	1.0000	0.0035	0.1330	
	Zarembo (ZRB)*	no	Middle and Outer Southern	4	19	4	1.0000	0.0089	0.1310	◊
British Columbian Islands	Bischof (BSF)	no	–	–	–	–	–	–	–	–
	Graham (GRM)	no	–	–	–	–	–	–	–	–
	Hotsprings (HTS)	no	–	–	–	–	–	–	–	◊
	Moresby (MRB)	no	–	–	–	–	–	–	–	–
	Ramsay (RMS)	no	–	–	–	–	–	–	–	◊

(Continues)

TABLE 1 (Continued)

Region	Location	Refugia	Hypothesized island group	*P. keeni*						
				n	*S*	*h*	*Hd*	π	F_{ST} (mean)	◊
	Vancouver (VCR)	no	–	–	–	–	–	–	–	–
Mainland	British Columbia (BC)	no	–	6	20	6	1.0000	0.0066	0.0652	◊
	Mainland Southeast Alaska (MLSE)	no	–	20	25	14	0.9370	0.0044	0.0362	–
	Northern mainalnd Southeast (NMLSE)	no	–	18	24	11	0.8820	0.0052	0.0505	–
	Interior Alaska, Yukon and White Pass (North)	no	–	2	2	2	1.0000	0.0018	0.0390	–
	Cleveland Peninsula (CP/MLCP)*	no	Inner Southern	–	–	–	–	–	–	–
	Foggy Bay (FB/MLFB)*	no	Middle and Outer Southern	–	–	–	–	–	–	–
	Glacier Bay (GB/MLGB)*	no	Outer Northern	–	–	–	–	–	–	–
	Haines (HNS/MLHNS)*	no	–	–	–	–	–	–	–	◊
	Interior Alaska (IAK/MLS)	no	–	–	–	–	–	–	–	–
	Juneau (JNO/MLJNO)*	no	Inner Northern	–	–	–	–	–	–	–
	Klukwan (KLU/MLKLU)	no	–	–	–	–	–	–	–	◊
	Misty Fjords (MFD/MLMFD)*	no	Inner Southern	–	–	–	–	–	–	◊
	Southeast Central (SEC AK/MLSEC)*	no	–	–	–	–	–	–	–	–
	Southeast North (SEN AK/MLSEN)	no	–	–	–	–	–	–	–	–
	Southeast South (SES AK/MLSES)	no	–	–	–	–	–	–	–	–
	Skagway (SKW/MLSKW)	no	–	–	–	–	–	–	–	–
	Taiya River (TYR/MLTYR)	no	–	–	–	–	–	–	–	–
	White Pass (WP/MLWP)	no	–	–	–	–	–	–	–	–
	British Columbia - Central (BCC)*	no	–	–	–	–	–	–	–	–
	British Columbia - North (BCN)	no	–	–	–	–	–	–	–	–
	British Columbia - South (BCS)	no	–	–	–	–	–	–	–	–
	Washington (WA)	no	–	–	–	–	–	–	–	–
	Yukon Territory - Central (YTC)	no	–	–	–	–	–	–	–	◊
	Yukon Territory - South (YTS)*	no	–	–	–	–	–	–	–	◊
Region	**Location**	**Refugia**	**Hypothesized island group**	***S. monticola***						
				n	*S*	*h*	*Hd*	π	F_{ST} (mean)	◊
Alaskan Islands	Admiralty (ADM)*	no	Inner Northern	4	3	4	1.0000	0.0013	0.1200	
	Baker (BKR)*	no	Middle and Outer Southern	2	0	1	0.0000	0.0000	0.5470	
	Baranof (BNF)	no	Outer Northern	–	–	–	–	–	–	

(Continues)

TABLE 1 (Continued)

				S. monticola						
Region	Location	Refugia	Hypothesized island group	*n*	*S*	*h*	*Hd*	π	F_{ST} (mean)	◊
	Chichagof (CGF)*	yes	Outer Northern	–	–	–	–	–	–	
	Coronation (CRN)*	yes	Coronation	2	6	2	1.0000	0.0055	0.3450	◊
	Dall (DAL)*	yes	Middle and Outer Southern	5	2	2	0.4000	0.0007	0.1680	
	Etolin (ETN)*	no	Middle and Outer Southern	2	3	2	1.0000	0.0027	0.0273	◊
	Forrester (FRS)*	yes	Forrester	5	3	3	0.7000	0.0013	0.3260	◊
	Gravina (GRV)*	no	Inner Southern	5	5	4	0.9000	0.0019	0.1110	
	Heceta (HEC)*	no	Middle and Outer Southern	4	4	3	0.8330	0.0018	0.3600	◊
	Kosciusko (KSC)*	no	Middle and Outer Southern	3	3	3	1.0000	0.0018	0.1670	
	Kuiu (KUI)*	no	Middle and Outer Southern	3	4	3	1.0000	0.0023	0.0450	
	Kupreanof (KRF)*	no	Middle and Outer Southern	5	3	2	0.4000	0.0011	0.0982	
	Lulu (LUL)*	yes	Middle and Outer Southern	3	4	3	1.0000	0.0023	0.5150	
	Mary (MRY)	no	–	–	–	–	–	–	–	
	Mitkof (MIT)*	no	Middle and Outer Southern	4	1	2	0.6670	0.0006	0.0134	
	Noyes (NYS)*	yes	Middle and Outer Southern	5	8	5	1.0000	0.0028	0.3370	◊
	Orr (ORI)	–	–	–	–	–	–	–	–	
	Prince of Wales (POW)*	no	Middle and Outer Southern	6	11	6	1.0000	0.0035	0.1150	
	Revillagigedio (REV)*	no	Inner Southern	5	10	5	1.0000	0.0040	0.0243	◊
	San Fernando (SNF)*	no	Middle and Outer Southern	3	1	3	1.0000	0.0009	0.5090	◊
	Suemez (SMZ)*	yes	Middle and Outer Southern	3	3	2	0.6670	0.0018	0.3070	
	Sukkwan (SWN)	–	–	–	–	–	–	–	–	
	Tuxekan (TXN)	no	–	–	–	–	–	–	–	
	Warren (WRN)	yes	Middle and Outer Southern	5	3	4	0.9000	0.0011	0.4480	
	Wrangell (WRG)*	no	Middle and Outer Southern	–	–	–	–	–	–	
	Zarembo (ZRB)*	no	Middle and Outer Southern	4	6	3	0.8330	0.0027	0.2320	
British Columbian Islands	Bischof (BSF)	–	–	–	–	–	–	–	–	
	Graham (GRM)	–	–	–	–	–	–	–	–	
	Hotsprings (HTS)	–	–	–	–	–	–	–	–	
	Moresby (MRB)	–	–	–	–	–	–	–	–	
	Ramsay (RMS)	–	–	–	–	–	–	–	–	
	Vancouver (VCR)	–	–	–	–	–	–	–	–	

(Continues)

TABLE 1 (Continued)

				S. monticola						
Region	**Location**	**Refugia**	**Hypothesized island group**	***n***	***S***	***h***	***Hd***	**π**	**F_{ST} (mean)**	**◊**
Mainland	British Columbia (BC)	no	–	2	8	2	1.0000	0.0073	0.0000	◊
	Mainland Southeast Alaska (MLSE)	no	–	26	12	9	0.6650	0.0014	0.0000	
	Northern mainalnd Southeast (NMLSE)	no	–	–	–	–	–	–	–	
	Interior Alaska, Yukon and White Pass (North)	no	–	–	–	–	–	–	–	
	Cleveland Peninsula (CP/MLCP)*	–	Inner Southern	–	–	–	–	–	–	
	Foggy Bay (FB/MLFB)*	–	Middle and Outer Southern	–	–	–	–	–	–	◊
	Glacier Bay (GB/MLGB)*	–	Outer Northern	–	–	–	–	–	–	◊
	Haines (HNS/MLHNS)*	–	–	–	–	–	–	–	–	◊
	Interior Alaska (IAK/MLS)	–	–	–	–	–	–	–	–	
	Juneau (JNO/MLJNO)*	–	Inner Northern	–	–	–	–	–	–	◊
	Klukwan (KLU/MLKLU)	–	–	–	–	–	–	–	–	
	Misty Fjords (MFD/MLMFD)*	–	Inner Southern	–	–	–	–	–	–	◊
	Southeast Central (SEC AK/MLSEC)*	–	–	–	–	–	–	–	–	
	Southeast North (SEN AK/MLSEN)	–	–	–	–	–	–	–	–	
	Southeast South (SES AK/MLSES)	–	–	–	–	–	–	–	–	
	Skagway (SKW/MLSKW)	–	–	–	–	–	–	–	–	
	Taiya River (TYR/MLTYR)	–	–	–	–	–	–	–	–	
	White Pass (WP/MLWP)	–	–	–	–	–	–	–	–	
	British Columbia - Central (BCC)*	–	–	–	–	–	–	–	–	
	British Columbia - North (BCN)	–	–	–	–	–	–	–	–	
	British Columbia - South (BCS)	–	–	–	–	–	–	–	–	
	Washington (WA)	–	–	–	–	–	–	–	–	
	Yukon Territory - Central (YTC)	–	–	–	–	–	–	–	–	◊
	Yukon Territory - South (YTS)*	–	–	–	–	–	–	–	–	◊

Note. Refugia = potential refugial islands and hypothesized island groups = island and adjacent mainland populations based on paleoshoreline reconstruction and LGM glacial cover = not included in the analyses that require the given information. Localities included in the Shimodaira-Hasegawa tests are indicated with asterisk. *n* = haploid sample size; *S* = variable sites; *h* = # haplotypes; *Hd* = haplotype diversity; π = nucleotide diversity; mean multilocus F_{ST}; ◊ = distinctive cyt *b* lineages.

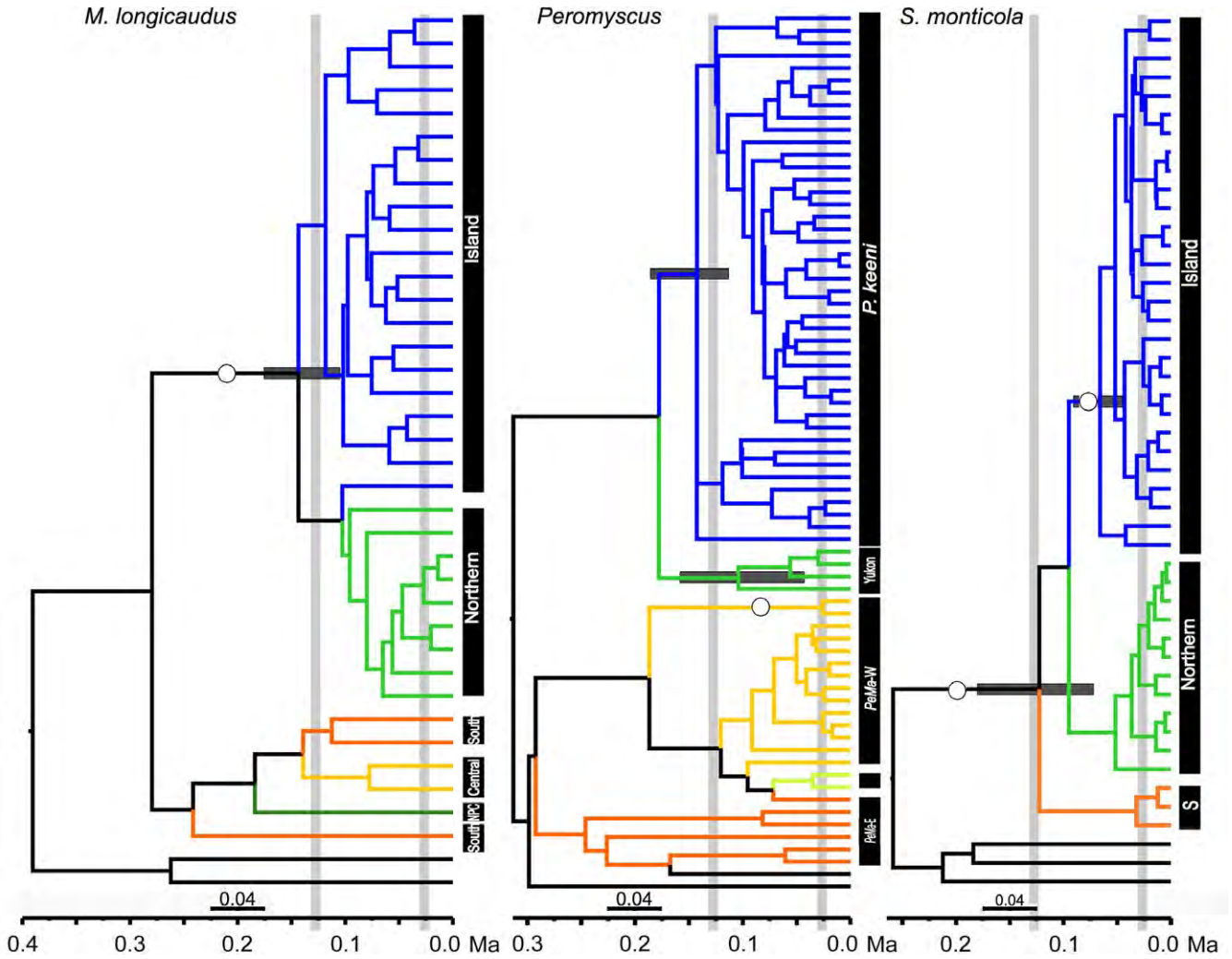

FIGURE 4 Multilocus Bayesian Species Tree. Posterior probabilities of ≥0.95 are represented with open circles on branches of the consensus tree. A priori groupings were designated based on cyt *b* Bayesian supported (≥0.95 posterior probability) clades. Blue = Island/*Peromyscus keeni*, bright green = Northern/*Peromyscus* sp. nov. (Yukon), dark green = North Pacific Coast, light yellow-green = Colorado Plateau/*P. maniculatus* Southwest, golden = Central/*P. maniculatus* West, orange = Southern/*P. maniculatus* East, black = outgroups. Horizontal gray bars represent divergence date estimates and vertical bars indicate approximate time for the LIG and LGM. LGM: Last Glacial Maximum; LIG: Last Inter-Glacial

were set as default. Models of LGM were averaged for final results using raster calculator in ArcGIS 10.1 (ESRI, Redlands, CA, USA). Climate suitability was limited by the low median threshold values over all replicates (Pearson, Raxworthy, Nakamura, & Peterson, 2007). Models were tested for performance using the randomization feature in ENMTools.

TABLE 2 Divergence date estimates for the island lineages of *Microtus longicaudus*, *Peromyscus keeni*, and *Sorex monticola* based on both cyt *b* and phased multilocus analysis

		cyt*b*			Multilocus		
Species	Lineage	95% HPD lower	Mean	95% HPD upper	95% HPD lower	Mean	95% HPD upper
M. longicaudus	Island	156,100	215,700	285,900			
	Northern/Island	296,500	402,000	516,400	108,900	143,500	179,300
Peromyscus	*P. keeni*	207,500	316,500	438,400	114,900	144,200	177,800
	Peromyscus sp. nov.	69,103	194,600	339,700	45,300	105,800	167,000
S. monticola		475,900	756,400	1,037,400	72,100	122,400	180,000
	Island	72,200	114,400	166,300	45,000	65,300	90,500
	Southern	49,900	130,200	219,800			

We estimated potential island refugia, connectivity within and among hypothesized island groups, and potential colonization pathways at different points since the LGM. To re-create paleoshorelines for three temporal periods: 20 kya (with LGM glacial cover), 14, and 10 kya (Ehlers & Gibbard, 2004), we used information available from Carrara et al., 2003 and Baichtal (pers. com.) in combination with

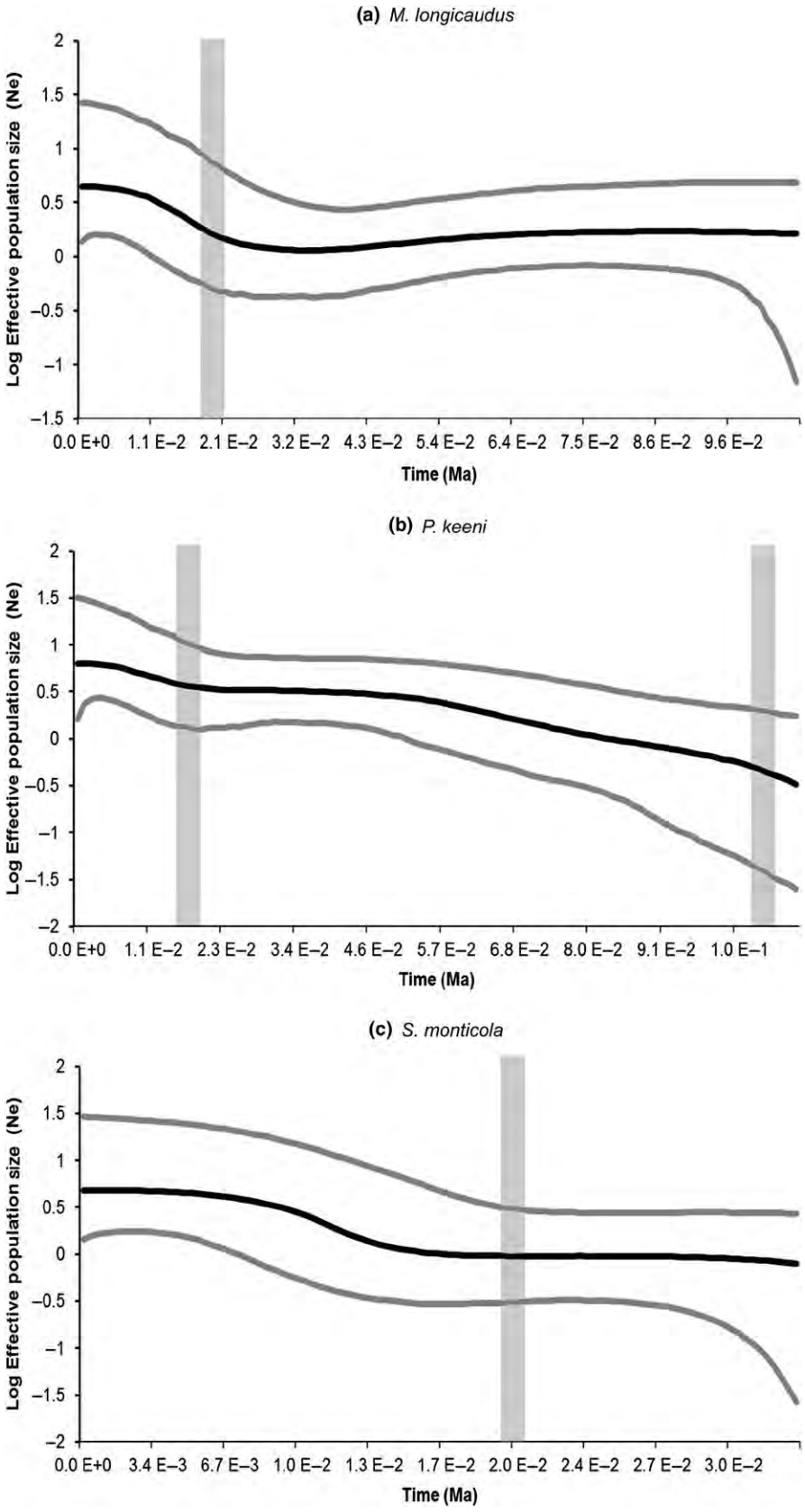

FIGURE 5 Cyt *b* Bayesian skyline plots (cyt*b* data only) for the major cyt*b* lineage populations: (a) *Microtus longicaudus* Island, (b) *Peromyscus keeni*, and (c) *Sorex monticola* Island. The *x*-axis right-to-left from past (TMRCA) to present and is scaled in millions of years and the *y*-axis is the log effective population size scaled by generation time. Vertical gray bars indicate the LIG (when applicable, right) and LGM (left) for reference. LGM: Last Glacial Maximum; LIG: Last Inter-Glacial

ArcGIS 10.1 to alter Southeast Alaska to sea levels suggested by estimates of historic sea levels and current bathymetric information (Baichtal & Carlson, 2010; Baichtal pers. Com.). These paleoshoreline reconstructions were then the basis for projected recolonization pathways for these terrestrial mammals.

For this study, AA populations were hypothetically designated as refugial or nonrefugial based on both paleoshoreline reconstructions (Figure 3; Table 1) and climate suitability as determined by the SDMs (Figure 2). Refugia were subaerially exposed, which reflects areas not covered by glacial ice, and not under water (i.e., regions of newly exposed continental shelf). If species persisted in refugia, paleoendemic island populations should show higher divergence than expected for island populations that are the result of recent (Holocene) colonization. Net mtDNA genetic divergences between hypothesized refugial (i.e., persistent) and nonrefugial (i.e., recently colonized) island populations were calculated in MEGA and standard demographic statistics were calculated for both mtDNA and nuDNA in DnaSP for all phased loci to test for varying histories (Table 1).

2.3 | Phylogenetic and demographic analyses

Lineage history was inferred through the use of a multilocus coalescent approach (Carstens & Knowles, 2007; Edwards, Liu, & Pearl, 2007; Maddison, 1997) with *Beast (Heled & Drummond, 2010) which uses a Bayesian Markov chain Monte Carlo (MCMC) algorithm implemented in Beast. All phased mtDNA and nuDNA loci were tested for molecular clock suitability and assigned as independent and unlinked and set with substitution models calculated in ModelTest (Supporting Information Appendices S3 and S4). A priori groupings were designated based on geographic populations (e.g., islands) with initial evaluation of cyt *b* data (Supporting Information Appendices S4 and S5). A lognormal relaxed clock was designated for Cyt *b* with the same rates as the Beast analysis (Supplementary text), while all rates for phased nuclear loci were estimated and assigned strict clocks. Each run consisted of random start trees with a Species Tree: Yule process prior and piecewise linear and constant root population size model with MCMC chain lengths of two billion iterations, sampling every two million. Tracer, awty, LogCombiner, and TreeAnnotator were used as in the Beast analysis (Supporting Information). PhyloGeoViz (Tsai, 2011) was used to visualize phased nuclear haplotype frequencies across the landscape.

Net genetic distances among major clades of cyt *b* were calculated in MEGA. To test for recent demographic change, we computed mtDNA and nuDNA summary statistics (segregating sites [*S*], number of haplotypes [*h*], haplotype diversity [*Hd*], and nucleotide diversity [π]), and selection and expansion statistics Tajima's (1989) *D*, Fu's (1997) Fs, and R_2 (Ramos-Onsins & Rozas, 2002) with 10 thousand coalescent simulations for each phased locus in DnaSP 5.10.1 (Librado & Rozas, 2009). Selection was also assessed through an HKA Test (Hudson, Kreitman, & Aguade, 1987).

To identify signals of population fluctuation, we estimated historical demography for the Island clades (clade includes both island populations and nearby mainland, and are distinct from Northern or Southern continental mitochondrial phylogroups) within cyt *b*, we generated Bayesian Skyline Plots implemented in Beast. Three runs per analysis used a MCMC chain of two billion steps, sampled every two million, with strict molecular clocks and models of evolution (Supporting Information Appendix S4) calculated via ModelTest. Tracer and awty were used to assess convergence.

3 | RESULTS

3.1 | Identification of potential refugial locations

Predictive performance for SDMs had mean AUC values of 0.801 ± 0.067 for *M. longicaudus*, 0.777 ± 0.080 for *P. keeni*, and 0.754 ± 0.082 for *S. monticola* across replicate runs, and all performed significantly better than random. No model clamping was detected. Suitable climate conditions for all three species in Southeast Alaska were present across all four temporal periods (Figure 2), including in areas west of the glacial ice during the LGM. Greatest suitability was for *P. keeni* for all historic periods. Future distributions suggest a decrease in habitat suitability for the outer southern islands and increased suitability for mainland regions for all three species (Figure 2). Paleoshoreline reconstructions (Figure 3) at 10 kya suggest four major island groups (outer northern, inner northern, inner southern, and outer southern and middle islands) with potential northern and southern coastal refugia at the LGM. By 8 kya, contemporary island topography was present. Post-glacial inter-island colonization pathways from refugial locations were inferred from island connectivity (Figure 3).

3.2 | Phylogenetic and demographic analyses

All loci across all species had varying levels of polymorphism and genetic diversity (Table 1 and Supporting Information Appendix S4), with mtDNA cyt *b* being the most variable locus. Among Island clades of all three species, *M. longicaudus* had the highest mtDNA haplotype diversity (98.4%), followed by *P. keeni* (97.8%), and *S. monticola* (76.4%). Nuclear haplotype diversity for *M. longicaudus* ranged from 12.4% to 18.2%, *P. keeni* 6.5%–39.1%, and *S. monticola* 4.1%–33.8%. Selection was not detected through HKA tests.

The multilocus species trees (Figure 4) for *M. longicaudus* reveal a single supported clade containing both Island and Northern cyt *b* clades. The species tree for *Peromyscus* lacked support for the Island clade (*P. keeni*). Species tree for *S. monticola* supports the Island clade and the Southern clade, and also indicates that *S. monticola* is monophyletic.

Nuclear haplotypes within the AA are broadly distributed across the archipelago and exhibit little geographic structure for all loci and all species, with the exception of ETS2 in voles. *Microtus longicaudus* populations on Forrester and Chichagof Island each have unique haplotypes for ETS2 (Supporting Information Appendices S6 and S7). Multilocus divergence dates (Table 2) for the Island-Northern clade of *M. longicaudus* and Island clades of *P. keeni* are near the LIG,

while the Island clade for *S. monticola* diverged earlier, between the LGM and LIG.

Within the AA, distinctive but minimally divergent, mitochondrial lineages are consistently recorded across the three species for Forrester, Noyes and Revillagigedo islands each, likely reflecting their contemporary isolation. Distinct island-specific lineages were also identified for Coronation, Dall, Kuiu, Lulu, Prince of Wales, and Zarembo for both *M. longicaudus* and *P. keeni*, and San Fernando for both *P. keeni* and *S. monticola* (Table 1; Supporting Information Appendices S5 and S8). Distinctive island lineages were recovered for Kupreanof, Suemez and Wrangell for *M. longicaudus*; while Admiralty, Baranof, Chichagof, Gravina, Heceta, and Warren were distinctive for *P. keeni;* and only Etolin was distinctive for *S. monticola* alone. Within *P. keeni*, the presence of a lineage representing the northern islands of Admiralty, Baranof and Chichagof is consistent with a biogeographic subregion first proposed by Swarth (1936; but see MacDonald & Cook, 1996).

Overall, measures of genetic diversity for the Island clades were low for all three species (Supporting Information Appendix S4), indicative of either population demographic expansions or selective sweeps. However, the inconsistent diversity indices among refugial versus nonrefugial islands could be a result of fixation (lower diversity) due to smaller island population size (Bidlack & Cook, 2002) compounded by a complex history of colonization and likely bottlenecked populations across the islands (Cook & MacDonald, 2013). Although significant expansion statistics can indicate selection, negative HKA tests suggest otherwise although we cannot rule out selection on closely linked regions. Additionally, significantly negative *D* and F_S for all cyt *b* may be a result of recently expanded populations. The cyt *b* skyline plots (Figure 5) for *M. longicaudus* suggests increase in effective population size (N_e) from a small ancestral population. In contrast to sudden growth in *M. longicaudus*, *P. keeni* and *S. monticola* show a steady increase in N_e. Additionally, growth occurs post-LGM within *S. monticola* and concurrent with the LGM for both *M. longicaudus* and *P. keeni*. Relative to mainland clades, high genetic diversity values for the Island clades of *M. longicaudus*, *P. keeni*, and *S. monticola* likely are the cumulative result of independent genetic drift within each island, with each of these fragmented island populations having relatively small N_e.

3.3 | Testing phylogenetic models under the Coastal Refugia Hypothesis

Differences in genetic divergence within and between areas identified as potential refugia by SDMs and those covered in ice were not detected (Supporting Information Appendix S9). Fu's F_S and Tajima's *D* and diversity indices (Supporting Information Appendix S4) varied in significance. The Bayesian skyline plots (Supporting Information Appendix S10) for all populations of *M. longicaudus*, *P. keeni*, and *S. monticola* are unable to distinguish between refugial and colonized areas.

4 | DISCUSSION

Phylogeographic studies help us understand how past environmental history has influenced genetic structure, but historical context (Grant & Grant, 2003) also provides a crucial foundation for forecasting how anthropogenic impacts, such as habitat conversion (e.g., old-growth logging) or climate-warming, will structure insular populations (Christensen et al., 2007; Fahrig, 2003; Olson, 1989). We found that genetic structure in three sympatric small mammals of the Alexander Archipelago was influenced by a complex history of deep isolation and subsequent colonization. Genetic footprints, combined with assessment of paleoecology, helps identify both past refugial locations and the contemporary geographic barriers that now structure populations. In the case of the AA, genetic structure in three co-distributed species was influenced by ice cover and lower sea levels—factors that left paleoendemic signatures reflecting their longer-term in situ divergence. Those isolates subsequently served as source populations for recolonization throughout the archipelago. A dominant feature in the data is an overall signal of island endemism and mainland demographic expansion, with idiosyncratic spatial (island) and temporal patterns among the three study species. Signals of overall demographic expansion among all three species across the entire AA and along the adjoining mainland are consistent with the Coastal Refugia Hypothesis, although details of histories differed across species.

4.1 | Shared geologic and climatic history

Historic SDMs are consistent with the paleoendemic signatures and identify that suitable environmental conditions existed in Southeast Alaska for these species during both the LIG and LGM (Figure 2). Multilocus estimates of divergence for *M. longicaudus*, *P. keeni* and *S. monticola* suggest pre-LGM initiation of regional divergence (Table 2). Coalescent simulations for both northwestern deer mice and dusky shrews are consistent with their long-term persistence in the region, with both *P. keeni* and the Island clade of *S. monticola* distinctive. Additionally, minimal intraclade variability and inter-island diversification characterized the Island clade of *S. monticola* (Figure 4 and Supporting Information Appendix S5). Coalescent simulations suggest a more recent divergence of *M. longicaudus*, potentially reflecting geographic proximity and relatively recent segregation (20 kyr) between contemporary populations representing the Island and Northern cyt b clades, rather than post-glacial expansion of mainland populations into the AA (Sawyer & Cook, 2016). Inconsistent estimates within each species partially stem from our inability to calibrate trees with fossils, and thus account for rate decay (Ho, Phillips, Cooper, & Drummond, 2005). Other signals (i.e., diversity indices, Fu's F_s; Tajima's D; Supporting Information Appendix S4) within *M. longicaudus* suggest a deeper history in Southeast Alaska, including their possible persistence and divergence in coastal refugia.

Demographic expansion was identified in the Island clades of all three species (Bayesian skyline plots and expansion statistics),

consistent with deglaciation of these areas (Figure 5; Supporting Information Appendix S4). All three Island clades have lower estimates of mitochondrial and nuclear diversity, compared to their continental counterparts, perhaps reflecting the influence of historically small population sizes. When tested as a single population, rather than individual islands, coalescent simulations (i.e. expansion statistics; Supporting Information Appendix S4) identified the source populations as originating from the islands of Southeast Alaska, rather than mainland. The deeper history of Island clades and relatively higher numbers of endemics within this coastal region for each species (Cook & MacDonald, 2001) is most consistent with their extended persistence in the region followed by contemporary isolation across the fragmented archipelago, a finding that corresponds to the history of ermine in the region (Colella et al., 2018).

Overall, there are signals of shared history across *M. longicaudus*, *P. keeni*, and *S. monticola*, but the idiosyncratic influence of mutation rates, selection and drift, combined with independent population-level responses to historical climate and variable pathways are potentially reflected in incongruent aspects of the phylogeographic patterns. Nuclear loci for all three species lack consistent signatures of geographic structure across the region (Figure 4 and Supporting Information Appendix S6 and Appendix S7), potentially due to a combination of incomplete lineage sorting and differential rates of male-biased dispersal (Foster, 1965; Helmus, Mahler, & Losos, 2014; McCabe & Cowan, 1945). The possibility of human-mediated transportation seems unlikely given island-specific resolution of mtDNA. The mtDNA data are not consistent with our original prediction that these widespread species should have relatively high levels of gene flow across the region. Instead, the data suggest that repeated genetic exchange or admixture during periods of lowered sea levels throughout the late Pleistocene and early Holocene have been followed by segregation and divergence in these species.

4.2 | Coastal Refugia Hypothesis

Although we are just beginning to explore the complex AA, preliminary studies suggest a significant role for northern coastal refugia in diversifying and structuring contemporary communities (e.g., de Volo et al., 2013; Hannon et al., 2010; Shafer et al., 2011). Reconstruction of paleoshorelines is complex due to non-linear changes as a result in lithospheric rebound (Josenhans, Fedje, Pienitz, & Southon, 1997) and submerged signatures of glacial extent, but our reconstructions of historical island connectivity, and potential colonization pathways suggest the potential for multiple LGM glacial refugia in Southeast Alaska (Figures 2 and 3): (a) mainland near Glacier Bay, (b) outer Baranof and Chichagof islands, (c) Forrester refugial complex, which would possibly result in post-glacial colonization through Prince of Wales, Zarembo and Mitkof islands, (d) Coronation refugial complex, colonization through Kuiu and Kupreanof islands, or (e) Annette-Duke refugium, south of Gravina Island. Deep ocean trenches likely would have forced recolonization of Admiralty, Wrangell, and Etolin islands from populations on the mainland, rather than from direct island connections.

Species distribution models (Figure 2) for each species suggest suitable climate supported offshore habitat on the exposed shelf and select western islands (Table 1) since at least the LIG. Relatively high levels of infraspecific differentiation and timing of interclade divergence, coupled with their absence from Baranof Island (and Chichagof for *S. monticola*) indicate that *M. longicaudus* and *S. monticola* likely persisted in coastal refugia along the southern extent of the AA. In contrast, *P. keeni*, likely persisted in a combination of northern and southern refugia within the AA, as suggested by the distinct cyt *b* lineage for the northern islands and differentiation across the southern islands. Unique haplotypes for *P. keeni* individuals from the islands of Haida Gwaii also present the option of coastal refugia near Haida Gwaii (Hetherington et al., 2003).

Cowan (1935) suggested both *P. keeni* and *S. monticola* survived the Wisconsinan glaciation in coastal refugia in the AA. Although Klein (1965) and others (Heaton & Grady, 2003, 2007) conclude all small mammals likely failed to survive the LGM, there are pre-LGM fossils of long-tailed voles from Prince of Wales Island (Heaton & Grady, 2003, 2007). Lack of fossils on Prince of Wales during the LGM does not eliminate the possibility, however, that these species persisted further west in coastal refugia on the continental shelf when oceans were >120 m lower during the LGM.

Presence of paleoendemic lineages has implications for the application of island biogeographic theory to the AA (e.g., Conroy et al., 1999), early human colonization of the New World (Achilli, Olivieri, Semino, & Torroni, 2018), and for understanding the evolution of continental biota (Riddle, 2016). Island isolation in particular may require special consideration as measurements of isolation generally assume the source population is on the mainland. If source populations for some species were actually from coastal refugia, then diversity measurements would be complicated due to multiple colonization sources and routes (Figure 3), a conclusion consistent with Lucid and Cook (2004) who showed that island area had more influence on contemporary island genetic diversity, than isolation (as measured by distance from the mainland). For example, the source for Prince of Wales populations would traditionally be measured from the mainland immediately to the east, but source populations might instead be from refugia to the west (e.g., Forrester or Coronation complexes).

Diversification of fauna in coastal refugia and then subsequently on the Alexander Archipelago also raises the possibility that continental diversity in northwestern North America has been influenced through recolonization of the mainland from islands (e.g., Filardi & Moyle, 2005). Each of the small mammals in this cohort appears to have a distinctive clade present in the AA which does not extend far beyond SE AK. The range of the Island clade of *M. longicaudus* is limited to the AA and nearby mainland, a distribution consistent with their paleoendemism in the region (Figure 1). The distributions in both *P. keeni* and the Island clade of *S. monticola* (south to Washington) extend beyond SE Alaska, but divergence dates, net genetic distance, genetic diversity, and expansion statistics, as well as models of refugial migration for *P. keeni* (Sawyer, Flamme, Jung, MacDonald, & Cook, 2017), suggest these species persisted along the coast during the LGM. The finding of an island paleoendemic

clade for all three species is consistent with the phylogeographic pattern uncovered for ermine (*Mustela erminea*) in the region (Colella et al., 2018), but differs somewhat from two other carnivores, Pacific Coast marten (*Martes caurina*) and black bear (*Ursus americanus*), where the distribution of the island lineages now extend far beyond the boundaries SE AK (Dawson et al., 2014; Fleming & Cook, 2002; Peacock et al., 2007; Small, Stone, & Cook, 2003).

5 | CONCLUSION

Historical climate and coastal refugia shaped genetic structure of species of the high-latitude Alexander Archipelago. Multiple lines of evidence suggest all three small mammals have paleoendemic lineages in the region, a finding consistent with other recent work on endemics in the region such as the Prince of Wales/Haida Gwaii ermine (Colella et al., 2018). Although this broad spatial pattern is concordant, questions remain regarding whether the timing of divergence coincides across these taxa. Cyclic climatic changes may produce similar spatial patterns that have different temporal signatures. Signals of demographic expansion across the region for these distinctive clades are also evident and roughly concordant. More detailed documentation of Late Quaternary changes in sea level and glacial cover along the North Pacific Coast, in addition to expanded genome-scale sampling of these and other endemic organisms, however, are needed to refine the number, location, and influence of glacial refugia.

Assessments of genetic structure across an array of species in complex landscapes, such as this coastal archipelago which experienced dynamic sea level fluctuations (e.g., Dolby et al., 2018), provide an initial framework for scientifically defensible management decisions (Gutrich et al., 2005; Pritchard, Jones, & Cowley, 2007). Future SDMs for these species forecast serious impacts, especially on the outer islands of the AA (Figure 2). Those outer islands now support a disproportionate number of subspecies (Cook & MacDonald, 2001) and endemic lineages of mammals (Cook et al., 2006) and other taxa (Sikes & Stockbridge, 2013). Those islands also have experienced extensive anthropogenic habitat conversion (e.g., clear-cut logging of old-growth forests) over the past six decades with only minimal monitoring of impacts on biodiversity (Cook et al., 2006; Orians & Schoen, 2013). More generally, similarities across species are identifiable through the use of integrated analyses (i.e., phylogenetic reconstructions, SDMs); approaches that could be extended to other taxa in the AA or other high-latitude fragmented systems, such as Haida Gwaii of British Columbia (Reimchen & Byun, 2006), the Japanese Archipelago (Millien-Parra & Jaeger, 1999), or British Isles (Vincent, 1990) to help conserve regionally distinctive biota experiencing dynamic environmental change (Avise, 2008; Hendry et al., 2010).

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CONFLICT OF INTEREST

None declared.

AUTHOR CONTRIBUTION

This research was part of the doctoral dissertation of Y.E.S. She is interested in the effects of historical climate on contemporary small mammals, particularly in the high latitude islands of Southeast Alaska. Y.E.S and J.A.C. developed the ideas; S.O.M. and J.A.C collected the specimens; Y.E.S. collected the genetic data in the laboratory of J.A.C; Y.E.S. analyzed the data; and Y.E.S., S.O.M., E.P.L. and J.A.C contributed to the writing.

DATA ACCESSIBILITY

Sample locations with museum numbers, latitude and longitude, major cyt *b* clade, and associated GenBank accession numbers (Supporting Information Appendix S1), as well as between group net genetic divergences of cyt b among refugial and nonrefugial Southeast Alaskan populations lineages of *M. longicaudus*, *P. keeni* and *S. monticola* (Supporting Information Appendix S9) are available from the Dryad Digital Repository: https://doi.org/10.5061/dryad.867g4c8.

ORCID

Yadéeh E. Sawyer https://orcid.org/0000-0002-8567-8261
Enrique P. Lessa https://orcid.org/0000-0001-9750-4093
Joseph A. Cook https://orcid.org/0000-0003-3985-0670

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Phylogeographic structure in long-tailed voles (Rodentia: Arvicolinae) belies the complex Pleistocene history of isolation, divergence, and recolonization of Northwest North America's fauna

Yadéeh E. Sawyer & Joseph A. Cook

Department of Biology and Museum of Southwestern Biology, University of New Mexico, MSC03 2020, Albuquerque, New Mexico 87131-0001

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Correspondence
Yadéeh E. Sawyer, Department of Biology and Museum of Southwestern Biology, University of New Mexico, MSC03 2020, Albuquerque, NM 87131-0001.
Tel: +(505) 277 1358;
Fax: +1 (505) 277 0304;
E-mail: yadeehsawyer@gmail.com

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Abstract

Quaternary climate fluctuations restructured biodiversity across North American high latitudes through repeated episodes of range contraction, population isolation and divergence, and subsequent expansion. Identifying how species responded to changing environmental conditions not only allows us to explore the mode and tempo of evolution in northern taxa, but also provides a basis for forecasting future biotic response across the highly variable topography of western North America. Using a multilocus approach under a Bayesian coalescent framework, we investigated the phylogeography of a wide-ranging mammal, the long-tailed vole, *Microtus longicaudus*. We focused on populations along the North Pacific Coast to refine our understanding of diversification by exploring the potentially compounding roles of multiple glacial refugia and more recent fragmentation of an extensive coastal archipelago. Through a combination of genetic data and species distribution models (SDMs), we found that historical climate variability influenced contemporary genetic structure, with multiple isolated locations of persistence (refugia) producing multiple divergent lineages (Beringian or northern, southeast Alaska or coastal, and southern or continental) during glacial advances. These vole lineages all occur along the North Pacific Coast where the confluence of numerous independent lineages in other species has produced overlapping zones of secondary contact, collectively a suture zone. Finally, we detected high levels of neoendemism due to complex island geography that developed in the last 10,000 years with the rising sea levels of the Holocene.

Introduction

Pleistocene glacial–interglacial cycles repeatedly affected divergence and speciation processes at high latitudes in both the Northern (Koch et al. 2006; Lee-Yaw et al. 2007; Godbout et al. 2008) and Southern Hemispheres (Lessa et al. 2010). In North America, the Laurentide and Cordilleran ice sheets extended far south during glacial phases (Dyke and Prest 1987; Roberts 1991; Carrara et al. 2007), resulting in major distributional changes in temperate and arctic species (Lyons 2003). As glaciers receded, deglaciated areas were recolonized by populations from refugia (Pielou 1991) and contemporary DNA footprints allow us to decipher the complex history of species movements following deglaciation (Hayes and Harrison 1992; Hewitt 2004; Marr et al. 2012). Populations that colonized de-glaciated regions have signatures of rapid population expansion (Hundertmark et al. 2002; Lessa et al. 2003; Walker et al. 2009), while refugial populations often reflect long-term stability (Rand 1954; Shafer et al. 2010;

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Stewart et al. 2010). Reconstructing recolonization patterns, however, can be problematic (Godbout et al. 2008), especially in topographically complex regions or when sampling is limited, because of the potential for cryptic (unsampled) refugia (Shafer et al. 2010), distinctive modes of expansion (e.g., phalanx and pioneer-type expansion, Hewitt 1996, 2000), and even selective sweeps when inference is based on a single gene (Excoffier et al. 2009). Furthermore, genetic variation in some recolonized populations may be higher than expected due to admixture between multiple lineages following expansion from independent refugia (Petit et al. 2003; Marr et al. 2008). Admixture may be particularly complex in high-latitude archipelagos when colonizing populations arise from multiple island source populations (Crawford et al. 2001).

Across the broad expanse of northern North America, a few regions have emerged as sites of high lineage diversity because they are at the confluence of multiple recolonizing lineages (Cook and MacDonald 2013). We focus on one of these regions, the panhandle of southeast Alaska along the North Pacific Coast, where high levels of lineage diversity is being documented for a growing number of species, (e.g., Dawson et al. 2014). These divergent lineages are postulated to have persisted in different ice-free regions [Beringian, southern continental, or coastal (Pielou 1991; Loehr et al. 2006; Carrara et al. 2007)] with subsequent expansion into proximity (Conroy and Cook 2000; Demboski and Cook 2001). Southeast Alaska, a region with an extensive island archipelago and high levels of endemism (Cook and MacDonald 2001), has been colonized by multiple newly arrived species (Cook and MacDonald 2013). This region also experienced substantial habitat modification in the past 80 years due to commercial logging and other extractive industries (List 2000; Schoen and Dovichin 2007; Albert and Schoen 2013).

We explore how complex topography and dynamic geologic history conspired to shape contemporary lineage diversity in *Microtus longicaudus* (long-tailed vole), a species that spans more than 35 degrees latitude across western North America in montane and mesic herbaceous habitats (Smolen and Keller 1987; Lomolino et al. 1989). Previous work based on a single mitochondrial gene identified a series of geographically discrete lineages and a single area of secondary contact in southeast Alaska (Conroy and Cook 2000). Divergence among coastal (island) and continental clades was attributed to late Quaternary glacial–interglacial cycling by Conroy and Cook (2000) who suggested the island clade experienced recent expansion from a southeast Alaska refugium with subsequent low gene flow among islands. The northern clade reflected pre-last glacial maximum (LGM) isolation, while the central and southern clades were the result of deeper (mid-Pleistocene) divergence.

By employing a multilocus approach and exploring historical climatic conditions predicted by species distribution models (SDM), we test previous phylogenetic hypotheses of lineage diversification across the broad range of *M. longicaudus* (e.g., Conroy and Cook 2000; Spaeth et al. 2009). We then revisit estimates of timing of divergence, refugial locations, and post-glacial colonization pathways through expanded geographic sampling. By focusing more intensively on the northwestern extent of the species' range, we first delimit the distribution and source of all lineages in the region. Second, through finer scale sampling, we begin to refine our understanding of the distributional edges of lineages to reveal areas of potential contact between distinct lineages and then test the hypothesis that these sites reflect postglacial (last 10,000 years) contact. Finally, through a combination of genetic data and species distribution models (SDMs), we examine the interplay between historical climate variability and contemporary fragmentation across an island archipelago to set the stage for detailed analyses of diversification and community assembly in this dynamic region.

Materials and Methods

Sampling and laboratory procedures

Museum specimens were obtained via fieldwork conducted annually since 1991. Frozen heart or liver tissues are archived at the Museum of Southwestern Biology ($n = 52$) and the University of Alaska Museum of the North ($n = 91$). Sampling now represents 46 localities spanning the geographic range of *M. longicaudus.* We focused most intensively on northwestern sampling to explore population structure across the Alexander Archipelago (AA) of southeast Alaska and identify the extent of contact between island and northern clades in southeast Alaska, with a higher sampling density near Haines ($n = 28$; Appendix S1; Fig. 1). Samples represented 11 of the 15 currently recognized subspecies of *M. longicaudus* (Fig. 1; Hall 1981). Additional cytochrome *b* gene (cyt *b*) sequences were obtained from GenBank for 67 individuals of *M. longicaudus*, one for each outgroup (*M. pennsylvanicus* and *M. montanus*), as well as a single Rag1 sequence for *M. pennsylvanicus* (Appendix S1).

Genomic DNA was extracted using Omega Bio-Tek (Norcross, GA) E.Z.N.A. kits or salt extraction (Fleming and Cook 2002), with final concentrations adjusted to 50 ng μL^{-1}. We amplified mitochondrial (mtDNA) cyt *b* (767–1143 bp, $n = 118$) and nuclear (nuDNA) gene

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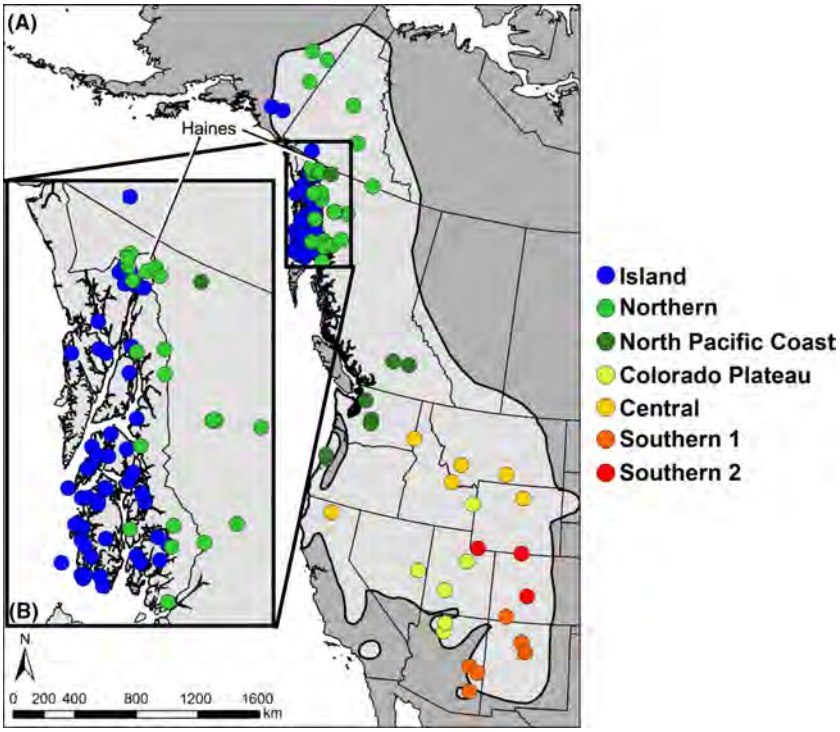

Figure 1. Current range of *M. longicaudus*. Light gray is the current range, black outlined regions. Dots are sampling locations colored by major cyt *b* clades (Fig. S1). (A) Entire range, (B) Haines and southeast Alaska.

sequences, including Protein C-est-2 (ETS2, 731 bp, $n = 71$), β-fibrinogen (FGB, 600 bp, $n = 101$), and recombination-activating protein 1 (Rag1, 1059 bp, $n = 83$; Table S1). Polymerase chain reaction, sequencing, visualization, editing, and phasing procedures for alleles were detailed in Sawyer (2014). All sequences were deposited in GenBank (Appendix S1).

Phylogenetic analyses and estimation of divergence times

We used a multilocus approach to reconstruct species relationships (Maddison 1997; Carstens and Knowles 2007; Edwards et al. 2007). The species tree was estimated in *Beast (Heled and Drummond 2010), which uses a Bayesian Markov chain Monte Carlo (MCMC) coalescent approach to coestimate multiple gene trees embedded within the corresponding species tree topology. *A priori* groups were based on geographic populations, with individuals within northern populations assigned based on cyt *b*-supported clades (Appendix S1 – "locality"). Independent, unlinked loci (mtDNA and each nuDNA locus) were partitioned by gene and set to appropriate substitution models (Table S2) calculated in ModelTest. An *a priori* uncorrelated lognormal relaxed clock was set for cyt *b* with a mutation rate of 4% Myr^{-1} based on previous estimates ranging from 3 to 5% Myr^{-1} (Conroy and Cook 1999; Brunhoff et al. 2003; Hope et al. 2013). Utilizing a Bayesian uncorrelated relaxed clock assists in reducing errors associated with recent divergence and the lack of reliable calibration points (Drummond et al. 2006; Ho and Duchene 2014). The tree priors were set to a Species Tree Yule Process with a piecewise linear and constant root population size model and random start tree. MCMC chain was run for 2 billion iterations, sampling every 2 million. Time to most recent common ancestor (TMRCA) was determined with a 95% posterior probability distribution in Tracer v1.5 (Rambaut & Drummond 2007). For each tree, convergence statistics were assessed with effective sample size (ESS) values ≥200 in Tracer and convergence onto the same tree was analyzed with the online software awty (Nylander et al. 2008). Three independent runs were checked for convergence in trace graphs then combined using LogCombiner v1.7.5, with a 10% burn-in. Tree files were annotated in TreeAnnotator v1.7.5, and topologies were visualized in FigTree v1.4.0 (Rambaut 2009). Because we lacked reliable fossils for this species, we were unable to incorporate fossil calibration into either cyt *b* (Data S1) or species tree analyses.

Migration estimates

We used BayesAss v3.0.3 (Wilson and Rannala 2003) to determine recent levels of gene flow among populations representing the major cyt *b* clades (designated with a 95% support for Bayesian and 70 for ML; Fig. S1) across

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the islands of southeast Alaska, as well as among northern populations with secondary contact or in close geographic proximity. BayesAss uses a nonequilibrium, multilocus Bayesian approach to estimate migration rates under a MCMC algorithm. We used phased multilocus data (mtDNA and nuDNA) and ran 200 million iterations with a 20 thousand burn-in and sampling every 2 thousand. Mixing parameters of allele frequencies, inbreeding coefficient, and migration rates were adjusted following program guidelines.

Demographic analyses

To explore the signatures of stability and postglacial expansion for each well-supported major cyt *b* clade, we reconstructed extended Bayesian skyline plots (EBSP; mtDNA and nuDNA) and cyt *b* Bayesian skyline plots (Heled and Drummond 2008) implemented in Beast. Colorado Plateau (COP) and North Pacific Coast (NPC) were omitted due to low sample sizes. Strict molecular clocks for all phased loci and appropriate models of evolution (Table S2) assigned for each of three independent runs per data set included a MCMC chain of 2 billion steps, sampled every 2 million steps. Tracer was used to assess convergence. Significant population size change occurred in EBSPs if zero was excluded from the 95% confidence interval (CI) of the estimate of the number of size-change steps (Lim and Sheldon 2011). To test for recent demographic fluctuation in cyt *b* major clades for each locus, we calculated a series of population genetic summary statistics [segregating sites (S), haplotype diversity (Hd), and nucleotide diversity (π)] for both mtDNA and nuDNA in DnaSP 5.10.1 (Librado and Rozas 2009). Historical demographic change or selection potential were assessed through Tajima's D (1989), Fu's Fs (1997), and Ramos-Onsin and Rosas' R_2 (Ramos-Onsins and Rozas 2002) with 10 thousand coalescent simulations. Selection potential was assessed through the HKA test (Hudson et al. 1987).

Species distribution models

We generated SDMs for *M. longicaudus* to identify regions of climate suitability across western North America, which were then tested with molecular data. Because we used relatively few southern samples, we did not generate clade-specific models. Models included bioclimatic variables obtained from WorldClim (www.worldclim.org, Hijmans et al. 2005) at a resolution of 2.5 arc-minutes for current, as well as mid-Holocene (~6 ka) and last glacial maximum (LGM; ~21 ka, http://pmip2.lsce.ipsl.fr/, Braconnot et al. 2007), and the last interglacial (LIG; ~120–140 ka). To avoid over-parameterization of the model, we used ENMTools (Warren et al. 2008, 2010) to eliminate highly correlated variables (Pearson correlation ≥0.75). Test layers were clipped to the extent of sampling, while projection layers were for western North America. Correlated bioclimatic variables were removed and only those judged to be the most important to *M. longicaudus* were retained for the final runs. Locality data were obtained from museum databases (e.g., ARCTOS http://arctos.data-base.uaf.edu and MaNIS http://manisnet.org/; Stein and Wieczorek 2004). Sites with large (>50 km) spatial errors were removed. Although genetic sampling was denser in the northern latitudes, that was not the case for SDMs (Fig. S2). To moderate spatial autocorrelation (Reddy and Davalos 2003), we reduced sample points to 50 km apart by removing intervening samples (Hope et al. 2011) for 149 final localities.

Species distribution models were constructed for each time period using MaxEnt v3.3.3k (Elith et al. 2006; Phillips et al. 2006; Phillips and Dudik 2008). Basic assumptions were as follows: no topographic change has occurred, niche conservatism (Wiens and Graham 2005), environmental data adequately predict species occurrence (Kozak et al. 2008; McCormack et al. 2010), and sampling records effectively captured the entire niche breadth of the species (Pearson et al. 2007). Final runs used bioclimatic variables 1 (annual mean temperature), 6 (min temperature of coldest month), 7 (temperature annual range), 9 (mean temperature of driest quarter), and 11 (mean temperature of coldest quarter) and were performed using cross-validation across 10 runs, with a random test percentage of 25%, regularization parameter of 5 (e.g., Hope et al. 2011; Warren and Seifert 2011), and 1000 iterations; all other values were default. Models were tested for performance using the randomization feature in ENMTools. Mean and median models were not significantly different from each other, so mean models based on MIROC and CCM models of LGM were averaged in ArcGIS 10.1 (ESRI, Redlands, CA) using the raster calculator. Minimum threshold values for climate suitability were the low median threshold values over all replicates (Pearson et al. 2007). These models were assessed with respect to potential refugial locations as identified by Sawyer (2014).

Results

Phylogenetic analysis

The multilocus species tree identified just a single well-supported clade (island and northern together; Fig. 2), while other clades identified based on mtDNA alone (Conroy and Cook, 2000; this study) were only moderately supported. Nuclear haplotypes (Fig. S3) generally were either

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lineage specific or shared across many individuals. Shared alleles were not dependent on geographic proximity, suggesting the lower resolution found in the species tree compared to the more geographically structured mtDNA tree may result from incomplete lineage sorting, rather than admixture (Toews and Brelsford 2012).

We found stronger geographic structure within the faster evolving cyt *b* across the range of *M. longicaudus* (Fig. 1 and Fig. S1), but all phylogenies were consistent with four geographic groups: (1) southern, comprised of two lineages (S1: Colorado and Wyoming; S2: New Mexico, Colorado, and Arizona); (2) central (California, Idaho, Montana, and Wyoming); (3) COP (Arizona into Idaho); and 4) northwest, consisting of NPC (British Columbia, Oregon, and Washington), northern (eastcentral Alaska, through Yukon and British Columbia), and island (southcentral Alaska, southern Yukon, and southeast Alaska). Two mainland southeast Alaska locations, Haines and Juneau, have representatives of both northern and island clades.

Both northern and island clades showed substantial internal structure, with many geographically restricted lineages identified (Fig. 2and Fig. S1).

Genetic diversity, demographic analyses and current levels of gene flow

Nuclear loci had varying levels of allelic diversity (Table S2), with ETS2 the most geographically structured. No selection was detected in HKA tests for all loci. Ramos-Onsin and Rozas R_2 values were significant for all loci. We inferred demographic history based on degree of genetic variation, significance of expansion statistics (Table S2), and both cyt *b* skyline plots and EBSPs (Fig. 3). Populations that experienced recent expansion generally have low *Hd,* while high *Hd* and π are indicative of long-term stability, and low *Hd* and high π suggest population bottlenecks. Levels of variation across all loci (mtDNA and nuDNA), although generated independently, were assessed for consistency across loci. The genetic signature of the island clade is consistent with a founder event that then experienced rapid growth, with high cyt *b Hd* a result of genetic drift in the small, fragmented populations of the archipelago. The northern clade signature is also consistent with reduced ancestral population size followed by rapid expansion, while the central clade was historically stable. The southern clade represents a glacially stable population that may have experienced a bottleneck (this signature only in the cyt *b* data). Small sample sizes for the NPC and COP clades preclude inference.

The mean of three runs for the Bayesian estimates of migration indicated low levels of gene flow between major cyt *b* clades within northern regions of secondary contact (Table 1), with the island clade the most genetically isolated. Gene flow (proportion of migrants derived from

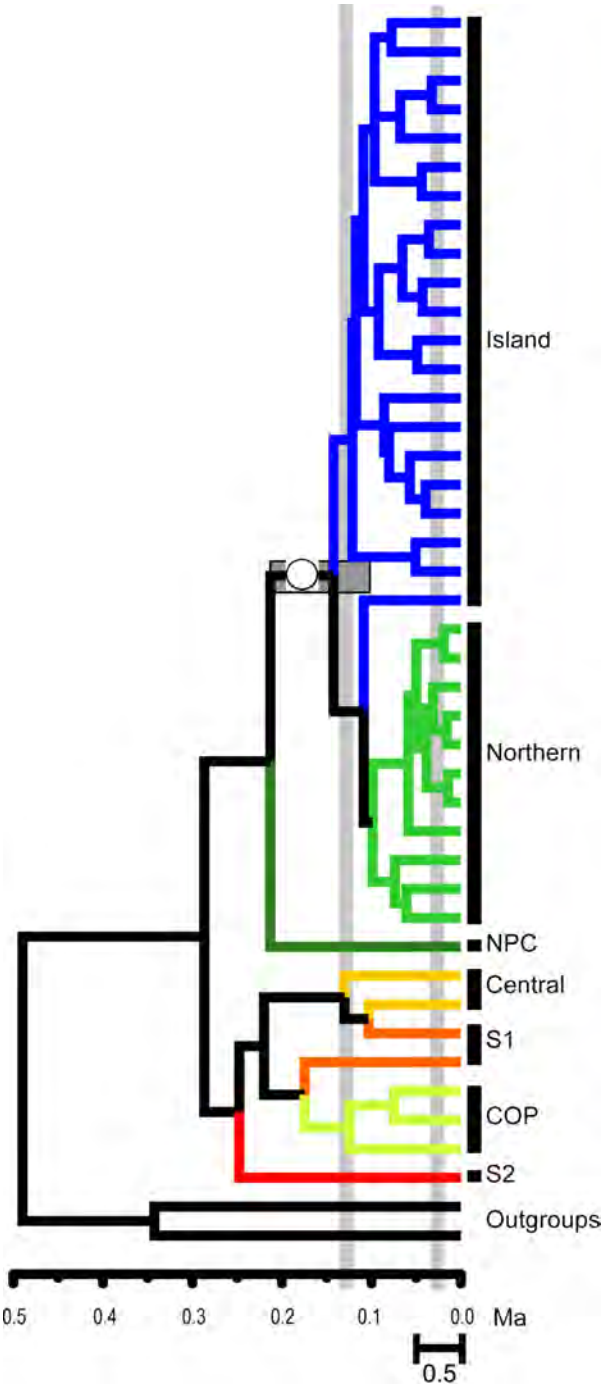

Figure 2. Phased multilocus Bayesian Species Tree. Posterior probabilities of ≥0.95 are represented with open circles on branches. Horizontal gray bars represent divergence date estimates and vertical bars indicate approximate time for the LIG and LGM. NPC = North Pacific Coast; COP = Colorado Plateau; S1 & S2 = southern clades.

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other populations) among geographically proximate representatives of distinct clades was highest from populations in the northern clade (Haines and Juneau) into the Haines population of the island clade (0.009–0.012; Fig. S4; Table S5). The island clade contained populations with a very small proportion of mainland migrants (<0.0187 between any island/adjacent mainland pair; Table S6).

Divergence times and alternate models of glacial refugia and postglacial recolonization

The multilocus estimation places the north/island clade TMRCA before the LIG (142 ka; Table S7; Cyt *b* estimates – Data S1).

Strong predictive ability of SDMs is indicated with AUC values >0.80 (Warren et al. 2008). SDMs in this study had predictive performances with a mean AUC value of 0.834 (standard deviation 0.04) for the training and test data and performed significantly better than random. The LIG SDM suggests *M. longicaudus* was restricted to coastal or extreme southern locations at this time, with a subsequent increase in climate suitability for the LGM in interior western North America, allowing northward and eastward movement. By the mid-Holocene, climate conditions were suitable to cover most of the current range of *M. longicaudus*. Because SDMs are conservative (i.e., limited by a minimum threshold value) and relatively few northern continental localities were included, the full northern range currently occupied was not predicted in the models (Fig. 4).

Discussion

Deciphering the dynamic history of a region sets the stage for interpreting how contemporary environmental change (e.g., deforestation, climate change) may impact species and ultimately ecosystems. In the case of coastal Alaska, our understanding of diversity, island biogeography, and community assembly across the vast Alexander Archipelago was predicated on the hypothesis that the region was entirely glaciated until about 12,000 years ago, and this suggested a narrow timeframe for colonization and diversification of the contemporary biota (Klein 1964). Subsequent phylogeographic (Cook et al. 2006; Shafer et al. 2010), geological (Carrara et al. 2007; Ager et al. 2010), and paleontological (Heaton and Grady 2003, 2007) investigations have revealed complex histories including deeper, in situ persistence and divergence for many species along the coast that were later followed by waves of colonization westward through the coast range from other ice-age refugia (Cook and MacDonald 2013).

Through the use of multilocus phylogenetics and SDMs, we explored how historical climatic events structured genetic variation in a common rodent across northwestern North America and then focused more intently on subsequent diversification across the islands of southeast Alaska. Sources for postglacial colonization of these northern latitudes typically were located in either southern ice-free regions (northward; e.g., Stone et al. 2002) or Beringia (southward; e.g., Eddingsaas et al. 2004). Because populations of taxa in the higher latitude deglaciated regions are hypothesized to be relatively homogenous due to recent northward expansion while southern source populations should retain signatures of long-term persistence and deeper divergence (Hewitt 2000; Lessa et al. 2003; Malaney and Cook 2013), we expected to find similar genetic signatures for *M. longicaudus*. Instead, we uncovered substantial structure in coastal Alaska, with admixture in some mainland populations that reflected complex histories of origin. Contemporary coastal mainland populations are derived from historically persistent (coastal refugial) populations in Southeast Alaska (Carrara et al. 2007) or derived from recent westward colonizers that arrived from one or more refugial sources outside of the region. Contemporary island populations in contrast are derived only from populations that persisted in or near the region (i.e., coastal refugium) and each of these insular populations subsequently has begun to diverge independently (neoendemics). We emphasize persistence "in or near the region" because the precise location of a LGM coastal refugium or series of refugia, when sea levels were up to 165 m lower, has not been identified. Intraspecific variability in this species at the far northwestern edge of its range mirrors to some extent the history of several other species studied to date, indicating that contemporary species in the region may be admixed as a result of contact between distinctive persistent and colonizing lineages. Similarly, contemporary communities in the region are a composite of both persistent and recently colonized species that arrived from multiple geographic sources (Cook et al. 2001, 2006). This dynamic

Figure 3. Cyt *b* Bayesian skyline plots (i) and EBSPs (ii) for the major cyt *b* clade populations: (A) island, (B) northern, (C) central, and (D) southern, excluding NPC and COP. EBSP central line indicates mean change in effective population size through time, with upper and lower lines showing the 95% posterior density. Significant population size change in EBSPs are indicated with asterisks. The x-axis right-to-left from past (TMRCA) to present and is scaled in millions of years and the y-axis is the log effective population size scaled by generation time. Vertical gray bars indicate the LIG (when applicable, right) and LGM (left) for reference.

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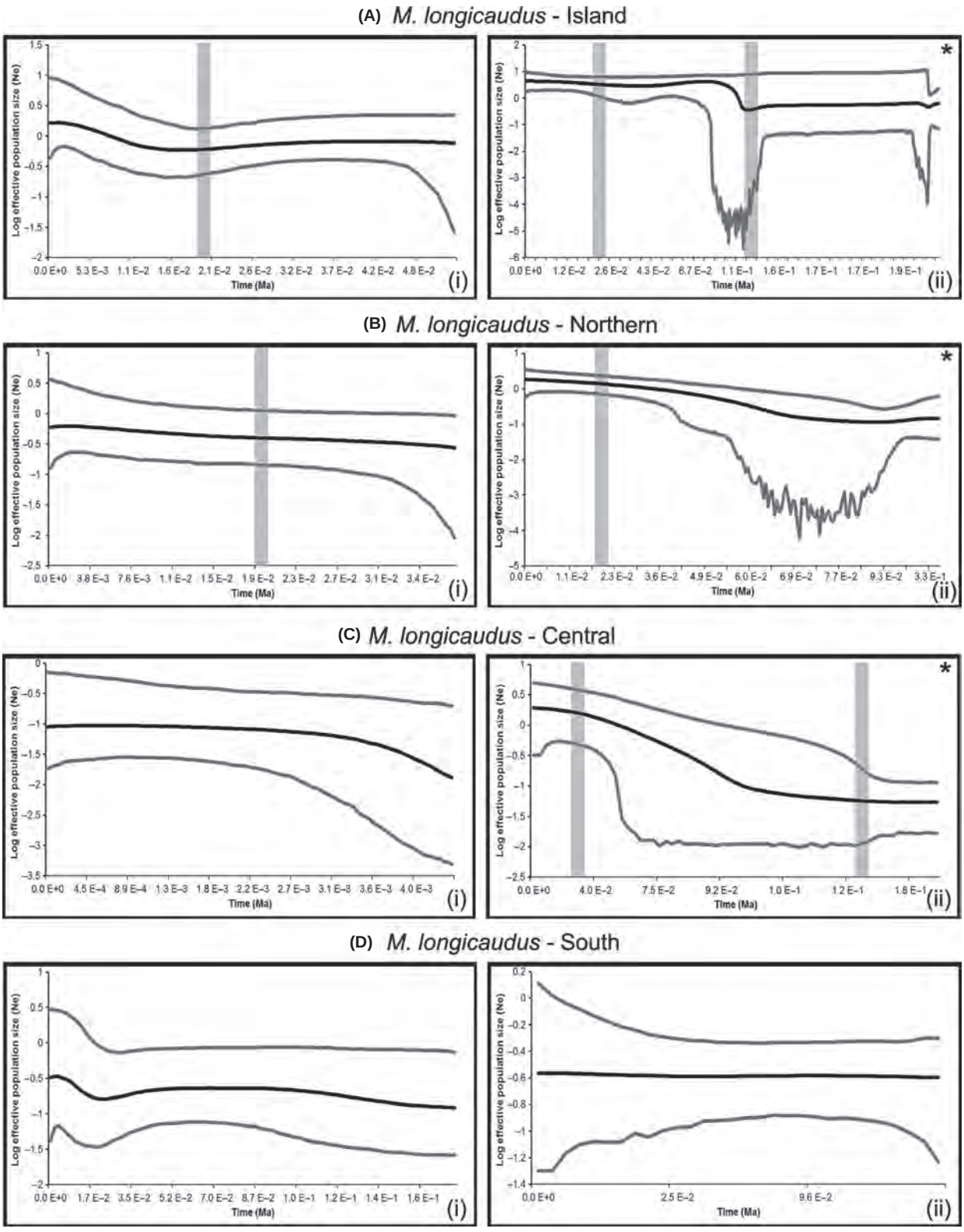

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Table 1. Major cyt*b* clade in regions of northern secondary contact. Bayesian migration estimates determined in BayesAss. Nonmigrants within each population are indicated in bold along the diagonal. Values are the proportion of migrant genes donated from source populations (columns) into sink populations (rows).

	Migration rates into...		
From...	Island	Northern	NPC
Island	**0.988**	0.007	0.005
Northern	0.019	**0.970**	0.011
NPC	0.050	0.156	**0.795**

perspective on assembly where species and communities may have multiple origins has broad implications ranging from new perspectives on the island biogeography of the archipelago, to revising conservation plans for this highly fragmented and heavily altered landscape and to establishing the history and critical roles of parasites in wildlife and zoonotic pathogens in humans in the region.

Biogeographic drivers of isolation, glacial refugia, and postglacial recolonization

This more detailed view of the phylogeography of *M. longicaudus* refines our understanding of divergence within southeast Alaska and largely corroborates earlier continental-scale work that revealed patterns of differentiation based on more restricted geographic and genetic sampling (Conroy and Cook 2000; Spaeth et al. 2009), but there are notable discrepancies. Spaeth et al. (2009) focused on the Greater Yellowstone Ecosystem, identifying postglacial subfossils representing both the northern and

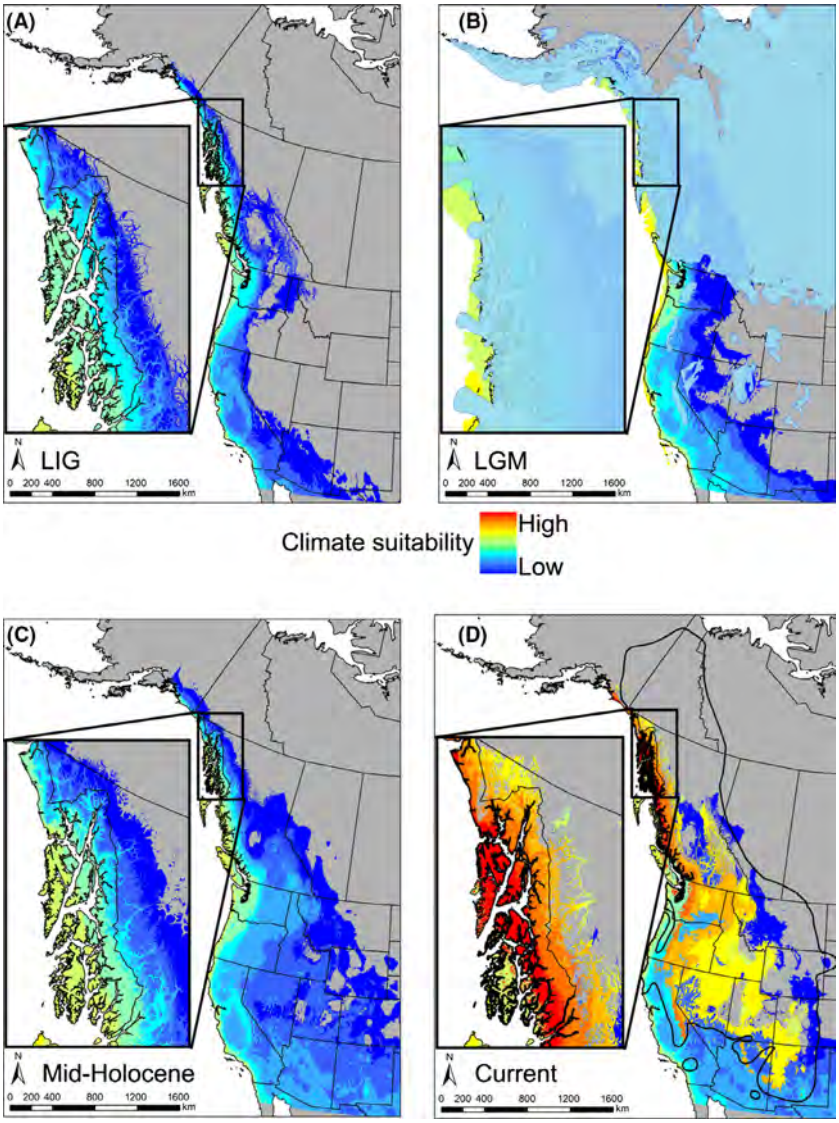

Figure 4. SDM output. (A) LIG (~125 ka), (B) LGM (~20 ka), (C) mid-Holocene (~6 ka), and (D) current time periods. The thick black line in (D) is the current range for *M. longicaudus*. The solid blue coloring in (B) is glacial ice cover. SDM climate suitability at each time period is limited by minimum median threshold values over all replicates. Because the SDMs are conservative, not all current localities are predicted in the models.

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central clades within Yellowstone (Fig. 5). Our expanded assessment detected substantial spatial and temporal patterns of genetic differentiation across the entire range of *M. longicaudus,* not previously identified by either Conroy and Cook (2000) or Spaeth et al. (2009).

The multilocus estimate for TMRCA of *M. longicaudus* is before the LIG (about 290 ka, Fig. 2), but is shallower than single-locus estimates from previous studies (340 ± 70 ka, Conroy and Cook 2000). Difficulty in establishing these estimates may reflect our inability to adequately calibrate trees with fossils and thus account for rate decay (Ho et al. 2005). Contrasting with the pre-LIG mtDNA estimates of divergence (Fig. S3), the shallower fossil dates are extending only to the Wisconsinan glaciation in Idaho, Wyoming, Colorado, and New Mexico (Schultz and Howard 1935; Anderson 1968; Harris 1970; Hager 1972; Walkerd 1982; White et al. 1984) and postglacial locations in Alberta and British Columbia (Harington 2011b). The absence of older fossils, especially at the northern extent of their range where we suspect refugial persistence (Guthrie 1968; Youngman 1975), may reflect poor preservation, lack of exploration of the region, or simply the difficulty of distinguishing vole fossil teeth (Harington 2011a). If the earlier DNA-derived estimate for initiation of separation (290 ka) is correct, then divergence among major lineages of *M. longicaudus* was likely reinforced through late-Pleistocene cycles of glacial isolation, as indicated by the SDMs (Fig. 4). Southern clades apparently experienced longer-term stability and isolation, while the strongly supported, yet shallow structure among most northern clades is due to recent (Holocene) range expansion.

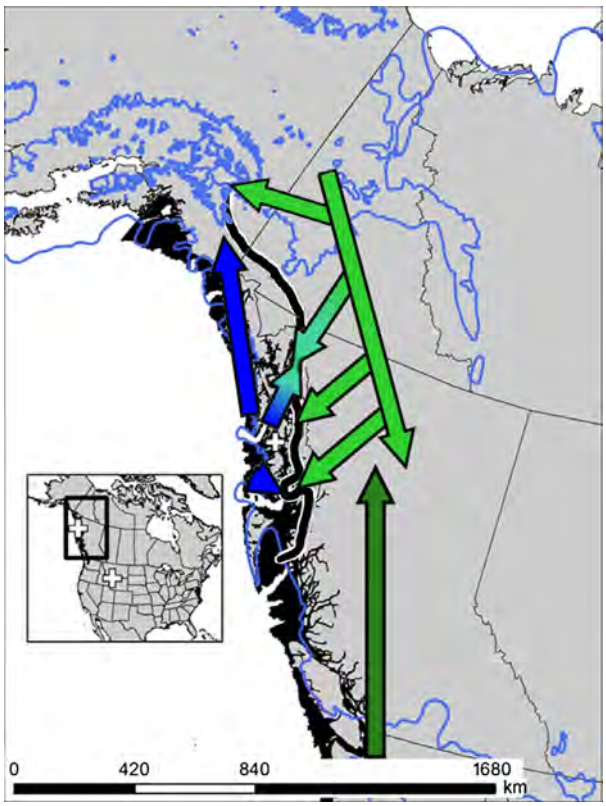

Figure 5. Proposed postglacial colonization routes (arrows) for *M. longicaudus* based on genetic signatures and SDMs. Plus (+) = fossil (SE Alaska)/subfossil (Yellowstone) locations and arrow colors correspond to current cyt *b* lineages: dark green = North Pacific Coast, green = northern, and blue = island. Northern and island clade refugial locations and postglacial colonization with location of geographic proximity indicated with the thick black line and secondary contact with converging arrows. Blue line indicates extent of glacial ice, and solid black coastal regions are exposed continental shelf at the LGM.

Our findings are consistent with the hypothesis that long-tailed voles persisted in a southeast Alaska coastal refugium (island clade) during the LGM, followed by expansion onto the islands and mainland and then recent isolation on multiple islands as sea levels rose (Fig. 5). Heaton and Grady (2007) found abundant *M. longicaudus* fossils from On Your Knees Cave (49-PET-408) on Prince of Wales Island (Fig. 5) that radiocarbon date to the middle Wisconsin Interstadial (38–25 ka), but fossil evidence disappeared by the LGM due to glacial advance onto this island. *Microtus longicaudus* reappeared in On Your Knees and El Capitan and Bumper caves on Prince of Wales Island by the early Holocene (Heaton and Grady 2003), which suggests rapid recolonization shortly after the LGM. The number of coastal refugial sites occupied by *M. longicaudus* should be further explored because SDMs and multilocus genetic signatures suggest the possibility that *M. longicaudus* persisted in up to three refugia within the AA. Fossil support for refugial locations in the AA may prove problematic, however, as much of the coast exposed during the LGM is now under up to 165 m of water (Carlson 2007; Shugar et al. 2014).

Lack of connectivity between insular populations produced extensive interisland structure, with populations on 13 of the 19 islands displaying island-specific haplotypes and significant mtDNA divergence (see also Sawyer 2014). Gene flow among island populations in the AA was inhibited due to sea-level rise during the early Holocene (c. 14–8 ka bathymetric reconstruction, Baichtal and Carlson 2010). Also, within the AA, *M. longicaudus* is the only vole that occurs on most of the islands (Baranof island is a curious exception). On the mainland of southeast Alaska, this vole is syntopic with two congeners, *M. oeconomus* (root vole) and *M. pennsylvanicus* (meadow vole); however, the phylogeographic histories of those two species remain poorly understood in the region. Both species are thought to be Holocene colonizers of

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southeast that originated outside of the coastal region (Cook and MacDonald 2013). With regard to other potentially closely associated species, the phylogeography of the ermine (*Mustela erminea)*, a vole specialist predator (Verts and Carraway 1998), has been explored. Three distinctive lineages of ermine, one endemic (island) and two originating outside the region (Beringian and southern) also have been identified in southeast Alaska (ermine; Fleming and Cook 2002; MacDonald and Cook 2007; Dawson et al. 2014), although there is limited spatial correspondence between the long-tailed vole and ermine lineages at finer spatial scales within southeast Alaska. The island lineage of *M. longicaudus,* for example, co-occurs with all three major clades (continental, Beringian, and island) of ermine. Hence, although the broader regional patterns of lineage divergence due to persistence in multiple glacial refugia are shared among this predator and its prey, idiosyncratic differences due to distinct colonization abilities, lineage persistence, or random events are evident on individual islands and on the mainland in southeast Alaska. These limited examples point to the need for more detailed comparative assessments with other taxa, such as plants and associated arthropods, across this complex landscape.

The island and northern clades of *M. longicaudus* have at least two points of secondary contact on the mainland (Haines and Juneau) and the multiple sites of geographic proximity southward along the mainland coast of southeast Alaska indicate the possibility of additional locations of contact between distinctive lineages (Fig. 4). Island individuals likely followed glacial retreat through multiple colonization pathways (Fig. 5) to recolonize the adjacent mainland while sea levels were low, while northern individuals apparently colonized the mainland rapidly through river corridors extending through the coast range after ice sheets receded. Detailed assessment of mainland sites based on increased sampling density is needed to interpret the expansion from the east, a process noted for other mammals (Cook and MacDonald 2013). This region of contact along the coast may reflect a generalized suture zone, where processes of introgression are similar to those detected in coastal populations of red-backed voles of the genus *Myodes* (Runck et al. 2009) and montane shrews, *Sorex monticolus* (Demboski and Cook 2001; Sawyer 2014). Contrary to previous suggestions that the northern clade of long-tailed voles expanded along a single interior route from south of the ice (Conroy and Cook 2000), we hypothesize that the northern clade persisted in Beringia and recently expanded southward into previously glaciated regions of southern Alaska, Yukon, and northern British Columbia (Fig. 5) as noted in moose, wolverine, ermine, and other species (MacDonald and Cook 2007). Two points that are potentially inconsistent with this conclusion are (1) lack of verifiable pre-Holocene fossils of long-tailed voles in Beringia, and (2) SDMs do not predict suitable environments north of the ice for long-tailed vole persistence during the LGM. We also recognize the possibility that with increased sampling across Yukon and British Columbia, either a more southern distribution of the northern clade may be detected, increasing the possibility of a southern (vs. Beringian) origin for this clade, or climatic niche suitability with a more northern range may be detected, supporting the Beringian origin for this clade. High levels of intralineage genetic diversity, net genetic distance among other clades, and the restriction of the range of this clade to high latitudes, however, are consistent with persistence in a northern refugium. Additionally, the species tree indicates a close association of the island and northern clades, suggesting a northern origin. Numerous paleontological as well as phylogeographic studies that identified genetic signatures point toward the persistence of many species in an eastern Beringia refugium during glacial periods, but clearly, there is a need for expanded analyses to further refine our understanding of these northern communities during the LGM (Fleming and Cook 2002; Stamford and Taylor 2004; Sawyer 2014).

Species distribution models are consistent with persistence of *M. longicaudus* along the coast of Oregon and Washington (NPC clade) during glacial advances. The central and southern clades were effectively isolated and relatively demographically stable since the mid- to late-Pleistocene. Lastly, the COP clade, previously identified from a limited region in northern Arizona, was found to occur northward into Utah and potentially contacts both the S2 subclade and central clade.

Contemporary genetic structure and current levels of gene flow

Deciphering signatures of incomplete lineage sorting versus secondary admixture is critical for interpreting how historical climate shaped contemporary distributions and genetic structure. Shallow divergence between northern and island populations near Haines may reflect recent (Holocene) secondary contact or incomplete lineage sorting. Future studies should incorporate more intensive sampling of individuals, especially in suspected contact zones, and expanded genomic coverage to explore potential admixture (Qu et al. 2012).

The distribution of major clades in *M. longicaudus* is generally inconsistent with subspecific designations (Fig. 1; Hall 1981). For example, Forrester and Coronation are identified as independent lineages, but these

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islands were previously placed in a single subspecies, *M. l. coronarius* (MacDonald and Cook 2009). All major clades span multiple subspecies of *M. longicaudus*, while several subspecies also include multiple clades. A reassessment of subspecies, originally based on morphological variation, is warranted.

Segregation of the northern/island clade from the NPC, COP, central, and southern clades is reflected in both the species tree (Fig. 2) and migration estimates (Table 1). The lack of support for deeper nodes may be a result of the relatively dense sampling for the northern/island clade. Compared to the northern clade, lower levels of gene flow from the island clade into the Haines area likely reflect physical barriers to movement (i.e., ocean straits, extant glaciers). Genetic exchange among island populations also is now limited, a finding that points to the possibility that these insular biotas are evolving independently and further reinforcing the urgency of managing this archipelago on an island by island basis, given that the AA comprises the largest federally managed forest in the United States, the Tongass National Forest (6.8 million ha).

Conclusions

Understanding the interplay between topography and historical climate change on both the distribution of contemporary species and the structure of genetic variation within these species sets, a powerful stage for forecasting and mitigating biotic responses to changing conditions. At a regional scale along the long-tailed vole's boundary in the Pacific northwest, significant structure reflects their dynamic expansion from multiple refugia concomitant with the contraction of glacial cover and as influenced by rising sea levels and isostatic rebound that played out over the complex topography of Pacific coastal North America. Similar processes of isolation and complex colonization along the North Pacific Coast were recently identified for this vole's primary predator, the ermine (Dawson et al. 2014). Our expanded view of molecular variation on 19 islands across the AA identifies the deeper signature of persistence in a coastal refugium that was the source for continental admixed populations and insular populations that are subsequently diverging, largely independently. Further work should focus on how species on individual islands will respond to changing environmental conditions, including a series of anthropogenic stressors (Hannon et al. 2010; Cook and MacDonald 2013) and rising sea levels. Recovering ancient DNA from the extensive fossil record from the region (>3000 specimens; T. H. Heaton, pers. comm.) would significantly extend our comprehension of temporal genetic variability (Miller et al. 2012) in this dynamic region.

Acknowledgments

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Data accessibility

Sample locations with museum numbers, latitude and longitude, major cyt *b* clade, and associated GenBank accession numbers are uploaded as online supplemental material in Appendix S1. PCR conditions are provided as Supporting information in Table S1.

Conflict of Interest

None declared.

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Appendix S1. Specimens examined.

Figure S1. Dated Bayesian cyt*b* trees.

Figure S2. Sampling localities for species distribution models.

Figure S3. Phased Bayesian gene trees for (A) ETS2, (B) FGB, and (C) Rag1 nuclear loci with posterior probabilities of ≥0.95 represented with open circles on branches of the solid consensus tree.

Figure S4. Phased nuclear haplotype distribution in Northern and Island clades of *M. longicaudus*.

Table S1. Primer list and PCR annealing temperatures.

Table S2. Diversity indices, expansion statistics and models of evolution.

Table S3. Between group net genetic distance.

Table S4. Locality abbreviations.

Table S5. Island and Northern cyt*b* clade populations near the geographic regions of contact (Haines and Juneau, Alaska).

Table S6. Bayesian migration estimates for Southeast Alaska populations determined in BayesAss for *M. longicaudus*.

Table S7. Cyt *b* and phased multilocus divergence date estimates.

Data S1. Cyt *b* data - Methods and Results.

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ORIGINAL ARTICLE

Diversification of deermice (Rodentia: genus *Peromyscus*) at their north-western range limit: genetic consequences of refugial and island isolation

Yadéeh E. Sawyer[1]*, Melanie J. Flamme[2], Thomas S. Jung[3], Stephen O. MacDonald[1] and Joseph A. Cook[1]

[1]*Department of Biology and Museum of Southwestern Biology, University of New Mexico, MSC03 2020, Albuquerque, NM 87131, USA,* [2]*National Park Service, Yukon - Charley Rivers National Preserve and Gates of the Arctic National Park and Preserve, 4175 Geist Road, Fairbanks, AK 99709, USA,* [3]*Yukon Department of Environment, 10 Burns Road, Whitehorse, YT Y1A 2C6, Canada*

*Correspondence: Yadéeh E. Sawyer, Department of Biology and Museum of Southwestern Biology, University of New Mexico, MSC03 2020, Albuquerque, NM 87131, USA.
E-mail: yadeehsawyer@gmail.com

ABSTRACT

Aim We surveyed the genetic variability of deermice (genus *Peromyscus*) at the north-western edge of their range to test for occupancy in multiple, hypothesized ice-free regions during the late Pleistocene and explore post-glacial dynamics.

Location North-western North America.

Methods We used sequences from four independent nuclear and mitochondrial loci from 341 specimens of *Peromyscus maniculatus, Peromyscus keeni* and *Peromyscus* sp. (Yukon) to assess species limits, population structure, and demographical change as a result of historical climate change, using a Bayesian approach. Species distribution models were built in MaxEnt to explore the niche overlap amongst genetically distinct species.

Results Divergence amongst three lineages began before the last interglacial, and each shows signs of post-glacial expansion. Multilocus species trees strongly support *P. keeni* and *Peromyscus* sp. (Yukon) as independent from *P. maniculatus*. Substantial substructure was observed for *P. keeni* across the fragmented Alexander Archipelago. Northern lineages or clades (*Peromyscus* sp. and *P. keeni*) differed in potential ecological distributions.

Main conclusions At the extreme north-western range of deermice in North America, three distinct lineages persist reflecting divergence in at least three ice-free regions [Beringia, Coastal (near Southeast Alaska) and Southern Continental] throughout the latest Pleistocene glacial cycles. Although spatially proximate in Yukon, no locations were identified where these lineages are in contact. Further, west along the Pacific Coast, *P. keeni* is widespread across the complex landscape of Southeast Alaska, yet there is limited contemporary gene flow amongst island populations, a finding consistent with the barriers produced by rising sea levels at the end of the Last Glacial Maximum.

Keywords
endemism, glacial refugia, *Peromyscus*, phylogeography, Southeast Alaska, Yukon

INTRODUCTION

Exploring evolutionary and geological processes that produced organismal diversity is a primary focus of phylogeographical studies. In north-western North America, Pleistocene (2.5 Ma–11.7 ka) glacial advances, for example, were hypothesized as crucial to the initiation of speciation (Mengel, 1964) and subsequent phylogeographical studies (e.g., Soltis *et al.*, 1997) have begun to illuminate the specifics of how glacial-interglacial cycles drove landscape fragmentation, isolation and subsequent population expansion and secondary contact (Taylor *et al.*, 2015). These dynamic events are recorded in the demographic signatures of expansion or stability in contemporary species (Hewitt, 1996; Lessa *et al.*, 2003).

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During the glacial periods, many north-western North American species persisted in ice-free regions, primarily south of the ice, or to the north in Beringia (Rand, 1954; Jorgensen *et al.*, 2003; Eddingsaas *et al.*, 2004), but other glacial refugia have also been proposed, such as along the Pacific Northwest coast (Fladmark, 1979; Fleming & Cook, 2002). Identifying the constituent species and characterizing the communities that persisted in the glacial refugia provides a basis for understanding the temporal and spatial dynamics of biotic response to climate change (Carstens *et al.*, 2013), permits forecasts of organismal response to future changes (Hope *et al.*, 2013b), and serves as a foundation for developing effective conservation strategies (Cook *et al.*, 2006).

Deermice of the genus *Peromyscus* (Cricetidae, Neotominae) are amongst North America's most speciose and widespread small mammals. Across the continental distribution of *Peromyscus maniculatus* (Wagner, 1845), for example, considerable variation in morphological characters exists and corresponds to wide environmental variability ranging from scrublands and deserts to forests and wetlands (Hall, 1981; Carleton, 1989; Hogan *et al.*, 1993). Based on the sequence variation in the cytochrome *b* mitochondrial (mtDNA) gene of this species, six major mtDNA lineages have been identified (Dragoo *et al.*, 2006; Kalkvik *et al.*, 2012): (1) Pacific Northwest and the Rocky Mountains, (2) Great Plains, (3) West Coast, (4) southern New Mexico and Mexico, (5) north-east United States and eastern Canada, and (6) north-east and north-central United States and south-central Canada. Phylogeographical structure and demographical signatures of expansion in this widespread species are largely consistent with other mammals that experienced range fluctuations during the Pleistocene (Brant & Orti, 2003; Runck & Cook, 2005), but high levels of mitochondrial differentiation and potential paraphyly with closely related species call into question the validity of *P. maniculatus* as a single species (Dragoo *et al.*, 2006).

In contrast, *Peromyscus keeni* (Rhoads, 1894), a species closely related to *P. maniculatus,* has a more restricted range, occurring primarily along the Pacific Coast, from northern Washington to southern Yukon. Phylogeographical studies suggest that *P. keeni* survived the Pleistocene in coastal refugia in either British Columbia (Zheng *et al.*, 2003) or Southeast Alaska (Lucid & Cook, 2004; Walker, 2005).

The north-western extent of the ranges of both *P. maniculatus* and *P. keeni* is in Yukon (Hall, 1981; Hogan *et al.*, 1993; Wike, 1998), where a presumably new species (herein *Peromyscus* sp.) was discovered that showed comparable mtDNA divergence with both *P. maniculatus* and *P. keeni* (Wike, 1998; Lucid & Cook, 2007). We used phylogeographical analyses of multilocus data to explore within and amongst species evolutionary dynamics and test hypotheses related to Pleistocene range fragmentation into multiple refugia, signatures of post-glacial expansion, and potential secondary contact of divergent lineages for these deermice at the northern extent of their range.

We hypothesize that three distinct signatures of glacial persistence and subsequent expansion will be present, which correspond to distinct refugia in far-eastern Beringia (mainland Alaska and western Yukon) for *Peromyscus* sp. (Wike, 1998; Lucid & Cook, 2007); north-western Pacific Coast (e.g., British Columbia, Southeast Alaska) for *P. keeni* (Zheng *et al.*, 2003; Lucid & Cook, 2004); and southern continent for *P. maniculatus* (Zheng *et al.*, 2003; Yang & Kenagy, 2009). Occupation of all three ice-free regions during the Last Glacial Maximum (LGM) would represent an uncommon pattern of persistence for glacial relics in this region (Cook *et al.*, 2001, 2006; Shafer *et al.*, 2010), with the possible exception of ermine (*Mustela erminea*, Dawson *et al.*, 2014), a predator of *Peromyscus*. We also evaluate how the strength of divergence affects the contemporary gene flow amongst clades within each species, with a focus on island populations along the Pacific Coast. Lastly, we evaluate the differences in the climatic niche requirements amongst putative species in light of the location of their glacial persistence.

MATERIALS AND METHODS

Sampling and DNA sequencing

A total of 341 archived specimens (tissues) representing 69 localities, spanning the geographical range of *P. maniculatus* and *P. keeni*, with more intensive sampling in Yukon and Southeast Alaska were analysed (Appendix S1 in Supporting Information; Fig. 1). Most specimens were collected by us over 25 years and deposited at either the University of Alaska Museum of the North (n = 235) or the Museum of Southwestern Biology at the University of New Mexico (n = 140). The University of Washington Burke Museum (n = 8) and Gwaii Haanas National Park Reserve and Haida Heritage Site (n = 7) also provided material. Additionally, 220 shorter cyt *b* sequences (479 bp) from across the geographical range of *P. keeni* were downloaded from GenBank (Zheng *et al.*, 2003; Lucid & Cook, 2004). Seven of eight subspecies of *P. keeni* and 17 of 27 subspecies of *P. maniculatus* were represented, including all six clades identified in previous work on *P. maniculatus* (Dragoo *et al.*, 2006; Kalkvik *et al.*, 2012).

Using either Omega Bio-Tek (Norcross, GA) E.Z.N.A. kits or standard salt methods, we extracted total genomic DNA to a concentration of 50 ng μL^{-1}. The complete mitochondrial (mtDNA) cytochrome *b* gene (cyt *b*, 1143 bp, n = 204) was amplified using primers L14734 (Ohdachi *et al.*, 2001) and CytBRev (Anderson & Yates, 2000). The following partial nuclear genes (nuDNA) were also sequenced (Sawyer, 2014), chosen based on variability within rodents observed in previous work, assessment within this study, and availability on GenBank: FGB (587 bp, n = 169) with primers MSB_PFGBF 5′ GCCGTTTGGATTGGCTGC 3′and MSB_PFGBR 5′ CGACAGGGACAATGATGGC 3′ (modified from Matocq *et al.*, 2007), IRBP (459 bp, n = 160) with primers MSB_PIRBPF 5′ CCAGGAGGTACTGAGTGAGC 3′ and MSB_PIRBPR 5′ GCTGAGTAGTCCATGCTAGC 3′ (modified from Stanhope

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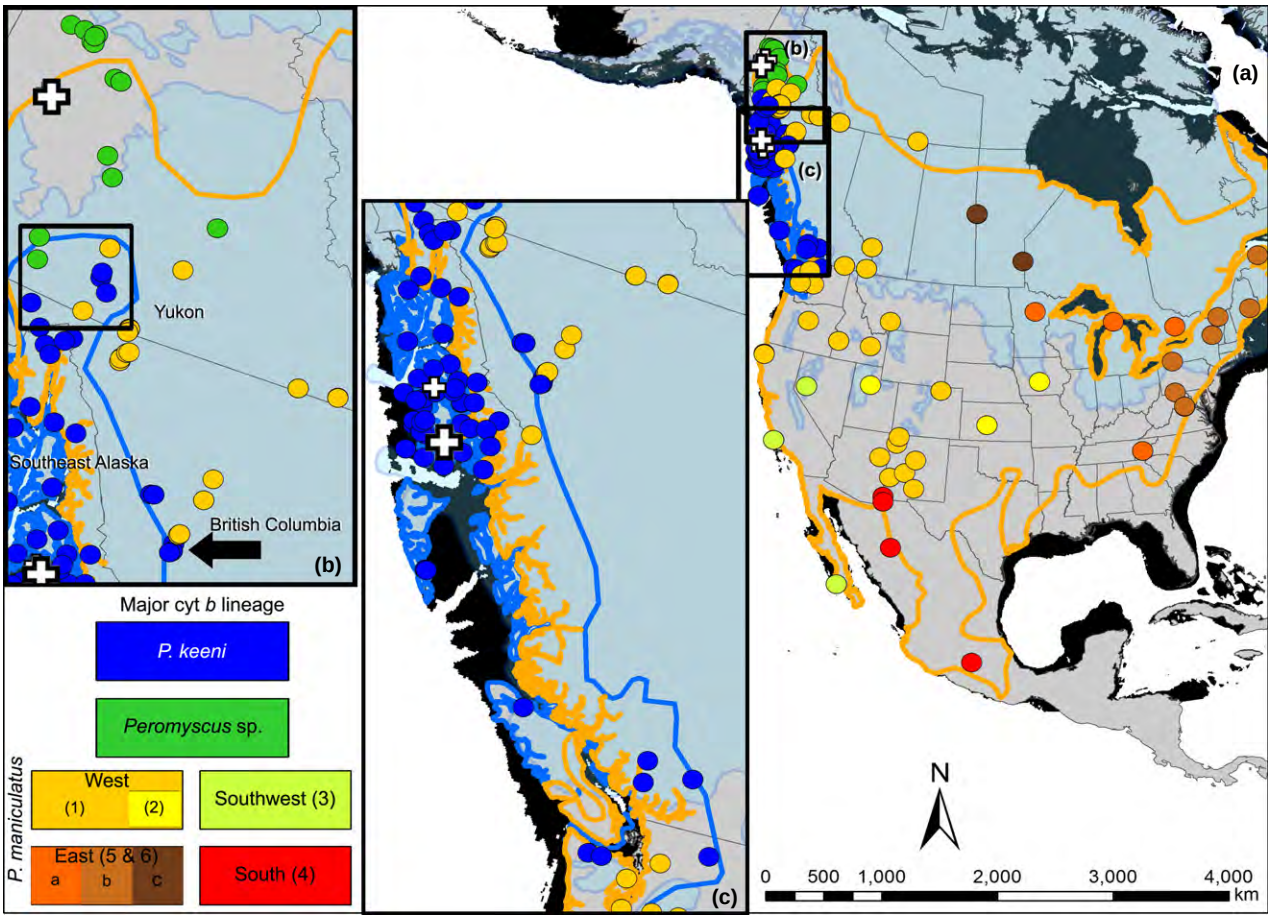

Figure 1 North American sampling scheme for deermice with the ranges of *Peromyscus maniculatus* (yellow line) and *P. keeni* (blue line) delineated. Solid light blue coloring is Last Glacial Maximum (LGM) ice cover. (a) Sampling localities are shown for both major cyt *b* lineages (numbers in parenthesis indicate previously designated lineage numbers from Dragoo *et al.*, 2006); (b) Yukon sampling with the arrow indicating an area of sympatry and box encompassing a region where three lineages are in close proximity; and (c) *P. keeni* localities and showing nearby samples of *P. maniculatus* West. Pluses indicate known pre-LGM fossil localities.

et al., 1992), and zona pellucida 3 (ZP3, 314 bp, n = 176) with primers Z36FA and Z37RA (Turner & Hoekstra, 2006).

Polymerase chain reaction (PCR) experiments used 1 μL DNA extract, 1 μL of each primer (2 mM), 1.5 μL PCR buffer (10x), 1.5 μL MgCl2 (25 mM), 1.25 μL of dNTP's (10 mM), 1.25 μL of Bovine Serum Albumen (BSA, 1.5 mM), and 0.08 μL of Ampli*Taq* DNA polymerase (Applied Biosystems, Foster City, CA, USA) and adjusted to a final volume of 15 μL with ddH2O. PCR products were cleaned using ExoSap-IT (Affymetrix, Santa Clara, CA). We used original PCR primers for automated sequencing at either the High Throughput Genomic Center (Seattle, WA, USA) or using an Applied Biosystems 3110 DNA sequencer (Molecular Biology Facility, UNM) with BigDye v3.1 (Applied Biosystems) chemistry.

Sequences were edited in SEQUENCHER 4.2 (GeneCodes Corporation), aligned in MEGA 5.2 (Tamura *et al.*, 2011) using the MUSCLE algorithm and checked by eye. Alleles of heterozygotes were inferred using five independently seeded runs of 1000 iterations with an initial burn-in of 1000 implemented in PHASE 2.1 (Stephens *et al.*, 2001; Stephens & Scheet, 2005). Iterations with the best goodness-of-fit were chosen. Posterior probabilities for nucleotides ≥ 0.85 were chosen; otherwise, ambiguous sites were coded as N. Only phased sequences were used for the analysis.

Phylogenetic analyses and timing of divergence

Multilocus approaches provide independent signals that contribute to the discovery of species' relationships (Maddison, 1997; Carstens & Knowles, 2007; Edwards *et al.*, 2007). The coalescent Bayesian Markov Chain Monte Carlo (MCMC) method implemented in *BEAST (Heled & Drummond, 2010) co-estimates species trees and contained gene trees. Because we lacked reliable fossils for deermice, we were unable to incorporate fossil calibration into either cyt *b* or species trees. *A priori* groups were based on discrete geographical populations (Appendix S1) with the initial evaluation of cyt *b* data (Appendix S2; Sawyer, 2014) guiding the distinction of sympatric lineages (e.g., *P. maniculatus* and *P. keeni* in Atlin, British Columbia). Loci were tested for molecular clock suitability. All available multilocus data

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(Appendix S1) were partitioned by independent, unlinked loci using an uncorrelated, lognormal relaxed clock for cyt *b* at a rate of 4% Myr^{-1} (Conroy & Cook, 1999; discussed in Brunhoff *et al.*, 2003 as divergence rate of 6–10% Myr^{-1}; Hope *et al.*, 2013a as mutation rate of 4% Myr^{-1}; Sawyer, 2014) whilst estimated nuclear loci used strict molecular clocks. Models of evolution (Table 1) were determined using ModelTest 3.7 (Posada & Crandall, 1998). Two billion iterations, sampled every 200,000 iterations, were performed using a random start tree under a species tree: Yule process tree prior, with a piecewise linear and constant root population size model. We used Tracer 1.5 (Rambaut & Drummond, 2007) to assess the effective sample size (ESS) values ≥ 200 and the software Awty (Nylander *et al.*, 2008) to assess the convergence. Runs with trace convergence and acceptable effective sample size (ESS; minimum of 200) were combined using LogCombiner 1.7.5, with a 10% burn-in and annotated in TreeAnnotator 1.7.5. Topologies were visualized in FigTree 1.4.0 (Rambaut, 2009).

Inferences of population history

We used DnaSP 5.10.1 (Librado & Rozas, 2009) to calculate the standard diversity indices for all samples, grouped by the major cyt *b* clades (Appendix S2), including segregating sites (*S*), haplotype diversity (*Hd*), and nucleotide diversity (π) for

Table 1 Diversity indices for *Peromyscus* sp., *P. keeni*, and *P. maniculatus* across North America, including expansion statistics and models of evolution. *n* = haploid sample size; L = length of sequence; S = variable sites; h = number of haplotypes; *Hd* = haplotype diversity; π = nucleotide diversity; *D* = Tajima's *D*; *FS* = Fu's *FS*; *R2* = Ramos-Onsin's *R2*; Model = model of evolution as selected by ModelTest. Bold values are significant at $P < 0.05$ ($P < 0.02$ for *FS*).

Group	Gene	*n*	L	S	*h*	*Hd*	π	*D*	*FS* ($P < 0.02$)	*R2*	Model of Evolution
All Samples	Cytb	260	1143	235	155	0.982	0.01861	**−0.10023**	**−0.82321**	**0.07836**	TrN+I+G
	FGB	168	479	23	22	0.309	0.00130	**−0.03746**	**−0.37821**	**0.07790**	HKY
	IRBP	160	421	7	7	0.080	0.00025	**−0.11871**	−0.96319	**0.07576**	HKY+G
	Zp3	176	314	6	8	0.067	0.00029	**−0.08499**	**−0.54854**	**0.07454**	GTR+I+G
No Out Groups	Cytb	258	1143	191	161	0.984	0.01722	**−0.09987**	**−0.86939**	**0.07861**	
	FGB	166	479	18	21	0.302	0.00117	**−0.02523**	**−0.34750**	**0.07931**	
	IRBP	157	421	7	7	0.081	0.00025	**−0.08041**	−0.61592	**0.07596**	
	Zp3	173	314	5	6	0.057	0.00022	**−0.07028**	−0.43458	**0.07501**	
Peromyscus sp.	Cytb	37	1143	42	22	0.946	0.00487	**−0.08122**	**−0.19581**	**0.11288**	HKY+I
	FGB	20	479	4	3	0.542	0.00312	−0.05602	−0.00642	**0.11819**	HKY
	IRBP	20	421	4	4	0.191	0.00070	**−0.02155**	**0.10754**	**0.13954**	HKY
	Zp3	17	314	10	8	0.574	0.00698	−0.07684	0.01352	**0.12065**	HKY+I
P. keeni	Cytb	103	1143	91	70	0.989	0.00529	**−0.07929**	**−0.33249**	**0.09185**	TrN+I+G
	FGB	86	479	2	3	0.057	0.00013	−0.08379	−0.47951	**0.08348**	HKY+I
	IRBP	74	421	3	4	0.243	0.00064	−0.00699	−0.11345	**0.09694**	HKY+I
	Zp3	89	314	10	12	0.222	0.00100	**−0.02895**	**−0.13447**	**0.09382**	HKY+I
P. maniculatus											
West	Cytb	90	1143	113	61	0.940	0.00860	**−0.09925**	−0.37647	**0.09386**	TrN+I+G
	FGB	44	479	23	21	0.753	0.00381	**−0.05620**	**−0.13547**	**0.09654**	HKY+I
	IRBP	47	421	8	9	0.343	0.00092	**−0.01808**	**−0.05135**	**0.10585**	HKY+I
	Zp3	50	314	4	5	0.153	0.00059	**−0.00082**	**−0.04361**	**0.10990**	HKY+I
East - a	Cytb	5	1143	16	5	1.000	0.00630	−0.05086	0.67799	**0.23149**	
	FGB	3	479	1	2	0.533	0.00111	−0.00688	0.33515	**0.29448**	
	IRBP	2	421	2	3	0.833	0.00238	−0.15870	0.39502	**0.34858**	
	Zp3	3	314	3	3	0.600	0.00391	−0.00619	0.33953	**0.26832**	
East - b	Cytb	7	1143	27	7	1.000	0.00700	**−0.06215**	0.47123	**0.19090**	
	FGB	4	479	1	2	0.250	0.00053	−0.01644	0.31732	**0.26876**	
	IRBP	5	421	2	3	0.511	0.00133	−0.01632	0.26473	**0.22699**	
	Zp3	5	314	6	5	0.867	0.00724	−0.04670	0.20722	**0.18491**	
East - c	Cytb	3	1143	9	3	1.000	0.00525	n/a	1.10130	**0.33813**	
	FGB	2	479	2	3	0.833	0.00209	−0.00377	0.36963	**0.34989**	
	IRBP	2	421	2	3	0.833	0.00317	−0.01828	0.39935	**0.33733**	
	Zp3	2	314	2	3	0.833	0.00319	−0.02415	0.37187	**0.34924**	
South	Cytb	3	1143	10	3	1.000	0.00583	n/a	1.13534	**0.33308**	
	FGB	3	479	2	3	0.600	0.00139	−0.00335	0.32780	**0.28936**	
	IRBP	3	421	7	5	0.933	0.00652	−0.03930	0.41737	**0.23530**	
	Zp3	3	314	8	5	0.933	0.01278	−0.04149	0.41630	**0.22276**	
Southwest	Cytb	10	1143	41	9	0.978	0.01091	−0.86630	0.35640	**0.16183**	
	FGB	4	479	0	1	0.000	0.00000	n/a	n/a	n/a	
	IRBP	4	421	1	2	0.536	0.00129	−0.02545	0.32683	**0.25466**	
	Zp3	4	314	2	2	0.536	0.00361	−0.04456	0.28652	**0.23280**	

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each locus (both mtDNA and nuDNA). Additionally, we calculated Tajima's *D* (1989), Fu's F*s* (1997), and R2 (Ramos-Onsins & Rozas, 2002) with 10,000 coalescent simulations to assess the historical demographical change or selection. The selection was further assessed through the Hudson-Kreitman-Aguadé (HKA) test (Hudson *et al.*, 1987). Additionally, we calculated the cyt *b* net genetic differences (Sawyer, 2014).

Extended Bayesian skyline plots (EBSP, Heled & Drummond, 2008) and Bayesian skyline plots were implemented in Beast to explore multilocus (mtDNA and nuDNA) and cyt *b* historical demography, respectively, for each *Peromyscus* sp., *P. keeni*, and *P. maniculatus* - West. Loci were unlinked and partitioned to their respective substitution models (Table 1) as determined using ModelTest. Loci were set to strict molecular clocks with rates for phased nuclear loci estimated based on 4% Myr^{-1} cyt *b* rate. Three independent runs per dataset included a MCMC of 2 billion steps (2 million intervals). We used Tracer 1.5 and Awty to assess the convergence. Significant population size change occurred if zero was excluded from the 95% confidence interval (CI) of the estimate of the number of size-change steps (Lim & Sheldon, 2011).

A combination of expansion statistics (Tajima's *D*, Fu's *FS*, and Ramos-Onsin's *R2*), measures of genetic variation (Table 1), and Bayesian skyline plots and EBSPs (Fig. 2) were used to assess whether populations representing major cyt *b* clades experienced stable conditions historically and whether there are detectable signs of expansion within both mtDNA and nuDNA. Inferences for all *P. maniculatus* East lineages and the Southwest and Southern clades were not made because of limited sampling.

Migration estimates

Among the species of *Peromyscus*, we estimated the potential gene flow between Yukon and nearby populations, as well as between Southeast Alaska populations of *P. keeni* using BayesAss 3.0.3 (Wilson & Rannala, 2003). BayesAss uses a non-equilibrium, multilocus (mtDNA and nuDNA) Bayesian approach to estimate the recent migration rates, under a MCMC algorithm. We ran 200,000 iterations with a 20,000 burn-in, sampling every 2000. Mixing parameters of allele frequencies, inbreeding coefficient and migration rates were adjusted following BayesAss guidelines.

To re-explore the previously hypothesized direction of post-glacial gene flow (Zheng *et al.*, 2003) using an expanded sampling scheme, and to identify the location of coastal refugia, we added 220 previously published cyt *b* sequences for *P. keeni* across their entire distribution, trimmed all sequences to match the minimal length (479 bp), and partitioned data into three population pairs or models: (1) Southern coastal refugium (Washington versus the remaining range), (2) either Southern or Northern coastal refugium (southern British Columbia, Vancouver Island and Washington versus northern British Columbia, Yukon and Alaska), and (3) Southeast Alaska refugium (Southeast Alaska islands versus all mainland populations). Models 1 and 2 are consistent with Zheng *et al.* (2003).

Ecological niche differentiation

Three major clades (identified as *P. keeni*, *P. maniculatus* - West, and *Peromyscus* sp.) occur in close proximity. To assess the differentiation with respect to the climatic requirements, we generated the species distribution models (SDMs) for *P. keeni*, *P. maniculatus* West and *Peromyscus* sp., for both western North America and areas north of central British Columbia. Nineteen bioclimatic variables for current conditions were obtained from WorldClim (www.worldclim.org, Hijmans *et al.*, 2005) at a resolution of 2.5 arc-min. To avoid over-parameterization, we used ENMTools 1.4.3 (Warren *et al.*, 2008, 2010) to eliminate highly correlated variables ($r \geq 0.75$), with final selection based on variables considered most biologically relevant. Test layers were clipped to the extent of sampling, whilst projection layers were for western North America. Species localities were confirmed with cyt *b* sequences rather than museum locality records because of the potential mis-identification. All non-repetitive sampling localities for *Peromyscus* sp. ($n = 14$), *P. keeni* ($n = 74$) and *P. maniculatus* ($n = 47$) were used.

Species distribution models were constructed using MaxEnt 3.3.3k (Elith *et al.*, 2006; Phillips *et al.*, 2006; Phillips & Dudik, 2008) under the following assumptions: no topographical change, niche conservatism (Wiens & Graham, 2005), environmental data adequately predicts species occurrence (Kozak *et al.*, 2008; McCormack *et al.*, 2010), and sampling records effectively capture the niche breadth of the species (Pearson *et al.*, 2007). Final runs used bioclim variables 1 (annual mean temperature), 6 (minimum temperature of the coldest month), 7 (temperature annual range), 9 (mean temperature of the driest quarter), and 11 (mean temperature of the coldest quarter) and were performed using cross-validation across 10 runs, with a random test percentage of 25%, and a regularization parameter (e.g. Hope *et al.*, 2011; Warren & Seifert, 2011) of 1 for *Peromyscus* sp. and 5 for *P. keeni* and *P. maniculatus*, with 1000 iterations. All other values were defaults. Models were tested for their performance using the randomization feature in ENMTools. Area under the curve (AUC) values of ≥ 0.80 were used to assess the predictive performance of SDMs. Minimum threshold values were the low median threshold values over all replicates (Pearson *et al.*, 2007). Using ENMTools, niche similarity was compared by calculating Schoener's D (Schoener, 1968), the *I* statistic (Warren *et al.*, 2008), and relative rank (RR; Warren & Seifert, 2011) between clades. Highly similar ranges have values approaching 1.0, whilst no range similarity is 0.

RESULTS

Sampling

Nucleotide composition varied across all loci (Sawyer, 2014), FGB and IRBP had no indels, whereas Zp3 had one indel of eight base pairs and another of a single base position. For each locus, evidence of selection was not detected (non-significant HKA).

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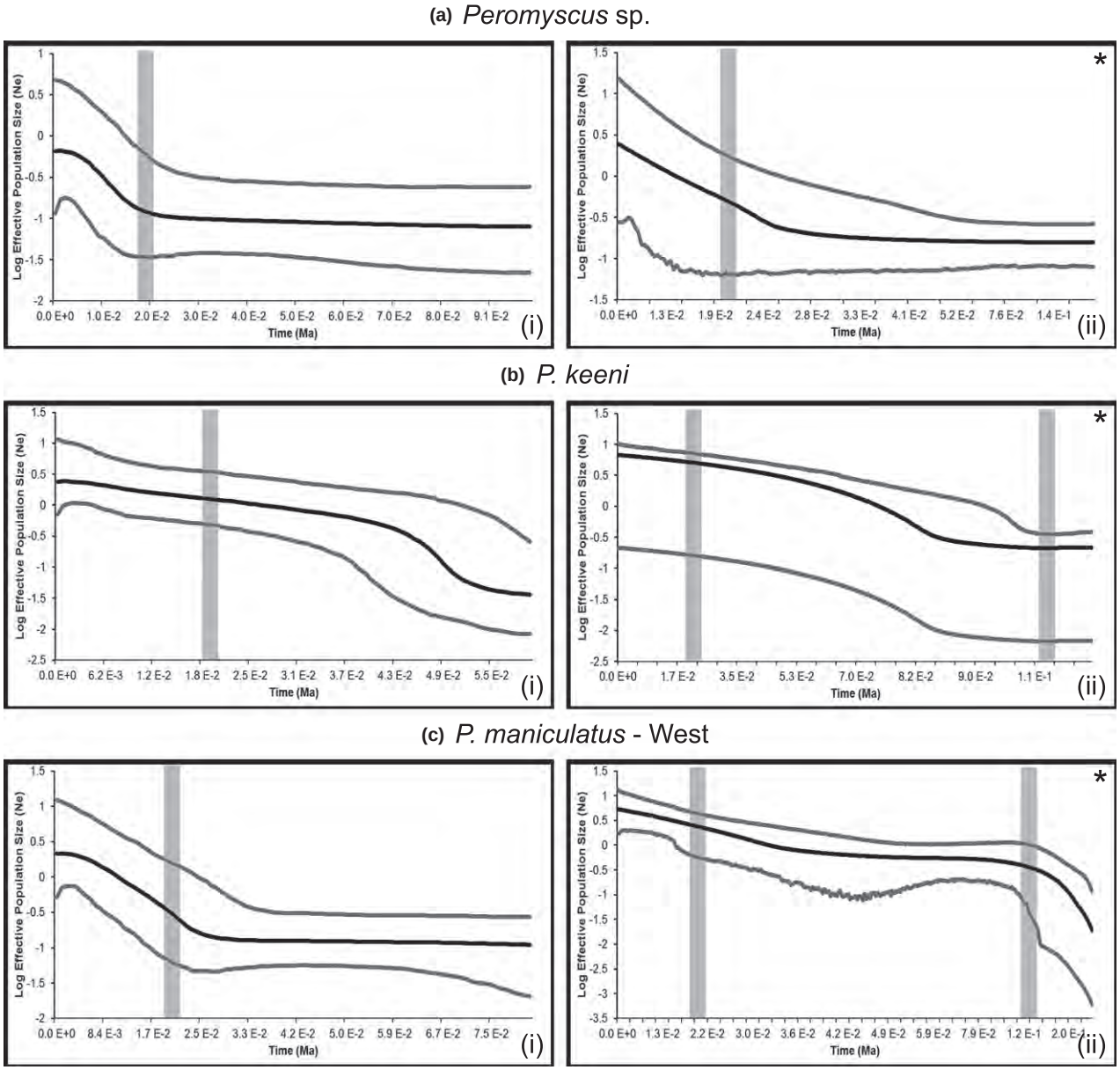

Figure 2 Cyt *b* Bayesian skyline plots (i) and EBSPs (ii) for the major cyt *b* lineage populations within North Amercia: (a) *Peromyscus* sp. (Yukon), (b) *P. keeni*, and (c) *P. maniculatus* West. EBSP Central line indicates mean change in effective population size through time, with upper and lower lines showing the 95% HDP. Significant population size change in EBSPs are indicated with asterisks. The *x*-axis right-to-left from past (Time to Most Recent Common Ancestor) to present and is scaled in millions of years and the *y*-axis is the log effective population size scaled by generation time. Vertical gray bars indicate the Last Interglacial (when applicable, right) and Last Glacial Maximum (left) for reference.

Phylogenetic analyses and timing of divergence

Species tree reconstruction (Fig. 3) yielded support for both *P. keeni* and *Peromyscus* sp. clades, and the British Columbia/Yukon clade within *P. maniculatus* West. Mean multilocus estimates of divergence times for these supported clades were estimated at between 69 and 160 ka (Table 2). Nearly, all other previously identified cyt *b* clades (Appendix S2; Sawyer, 2014) were detected but not significantly supported in the species tree. Recent diversification of these geographically structured groups is likely reflected by incomplete lineage sorting, relatively short branches, and overall weak support (Sawyer, 2014).

Inferences of population history

High *Hd* and π indicate stability, low *Hd* and high π may identify population bottlenecks, and low *Hd* and π are typical of recently expanded populations (Tajima, 1989; Fu, 1997). Across the three species we examined, all generally showed signatures of recent expansion (Table 1), although

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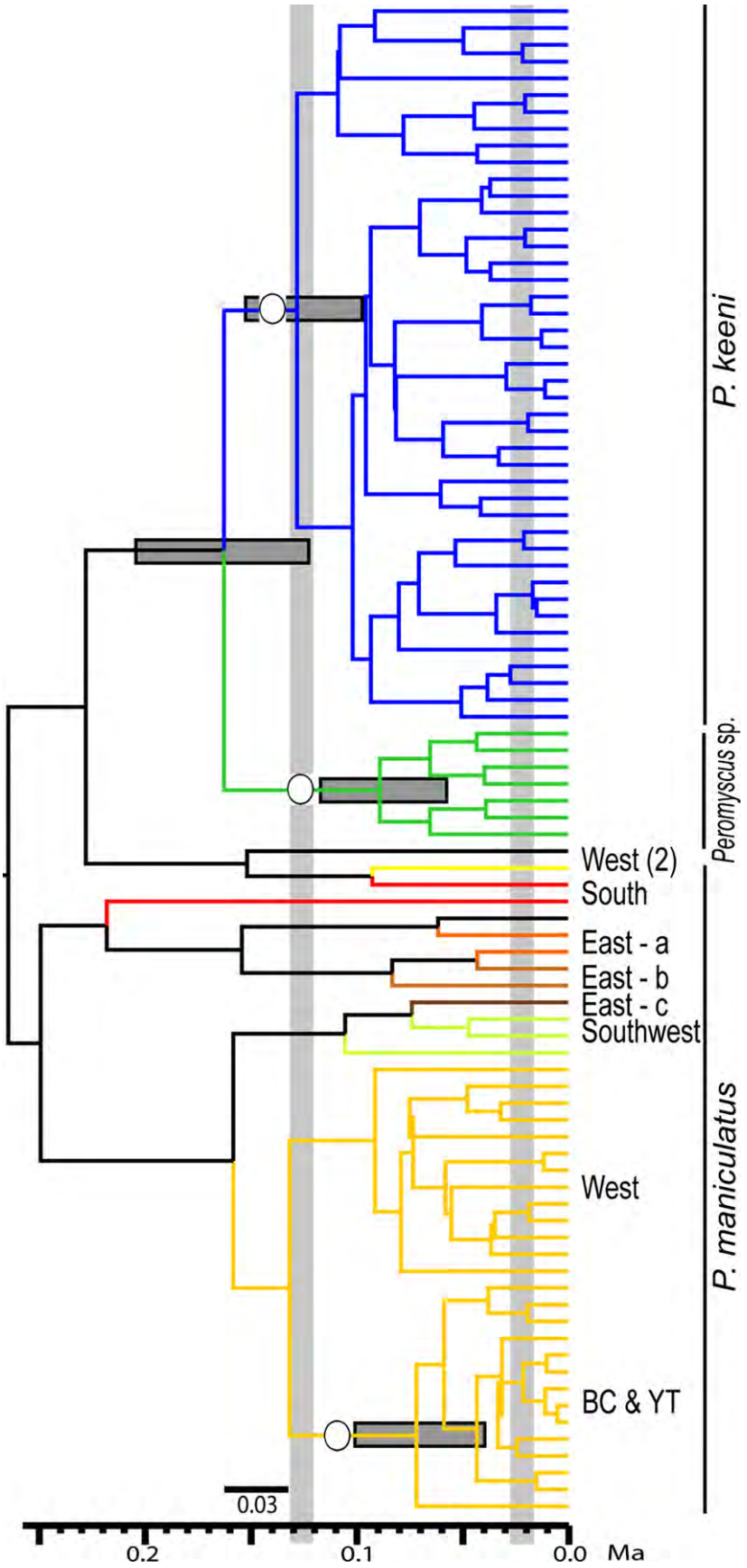

Figure 3 Multilocus Bayesian species tree for *Peromyscus* sp., *P. keeni*, and *P. maniculatus*. Posterior probabilities of ≥ 0.95 are represented with open circles on branches of the solid consensus tree. Black = outgroups (*Peromyscus melanotis* and *P. leucopus*). Horizontal gray bars represent divergence date estimates and vertical bars indicate approximate time for the Last Interglacial and Last Glacial Maximum.

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Peromyscus sp. reflected mixed signals across genomes, with skyline plots suggesting recent expansion. Percentage net genetic distance (Sawyer, 2014) based on cyt *b* ranges from 0.3 ± 1.5% between *P. maniculatus* East - b and *P. maniculatus* East - c to 4.8 ± 0.6% between *Peromyscus* sp. and *P. maniculatus* East - c, in addition to the 0.9–14% (± 0.9–13.7%) between each cyt *b* lineage with known outgroups, *P. leucopus* and *P. melanotis*.

Migration estimates

Bayesian estimates of recent migration (mean across three runs) between Yukon and northern British Columbian populations indicate *Peromyscus* sp. has the highest proportion of immigrants from Yukon *P. keeni* (0.096), with much smaller flow (0.01) from *P. maniculatus* West from Yukon (Sawyer, 2014). *Peromyscus keeni* in Yukon has a small proportion of immigrant genes (0.012) from *Peromyscus* sp. and *P. maniculatus* West (0.008) from Yukon. Similarly, Yukon *P. maniculatus* West shows low levels of introgression (0.024) from Yukon *P. keeni* and from *Peromyscus* sp. (0.013). Population pairwise comparisons (Sawyer, 2014) for *P. keeni* revealed low levels of gene exchange (≤ 0.0185) between any island or adjacent mainland populations, and only slightly higher migration from islands of the Alexander Archipelago (AA) onto the mainland than the converse (0.0049 and 0.0019, respectively). Much greater differences in gene flow were detected in the Southern coastal refugium (0.18 from north of Washington southward versus 0.0016 from Washington northward), and either Southern (0.1152 from North to South versus 0.0016 from South to North) or Northern coastal refugium (0.0049 from AA to Mainland versus 0.0019 from mainland to Islands) models with clear north to south gene flow (Table 3).

Ecological niche differentiation

All niche models performed significantly better than random. Highest climate suitability (Fig. 4) for *Peromyscus* sp. occurs in higher latitudes, along the Pacific Coast for *P. keeni*, and non-montane regions across the West for *P. maniculatus*. Greatest potential range overlap, based on ENM Tools for Niche Overlap is between *Peromyscus* sp. and *P. maniculatus* West with average overlap of 0.836. Least overlap was between *Peromyscus* sp. and *P. keeni* (average overlap = 0.498; Appendix S3).

DISCUSSION

Pleistocene climatic fluctuations influenced the diversification of the North American biota because of the repeated segregation of species into refugial populations (Hewitt, 1996), and this cyclic history is reflected in substantial phylogeographical structure in wide ranging species (Malaney *et al.*, 2013). Late Pleistocene glacial cycling, in particular, shaped diversification within north-western *Peromyscus*, with multilocus tests supporting the presence of three distinctive deermice near the extreme north-western boundary of their range. Spatially extensive sampling and use of phylogenetic coalescent analysis, multilocus sequence data, and environmental modelling, provide insight into geographical variation and the role of refugial locations and colonization dynamics in producing contemporary species.

Effects of glacial persistence and migration on genetic and ecological differentiation

For the *P. maniculatus* complex in north-western North America, signatures of expansion (expansion statistics, EBSP/BSP), topology of species trees, analyses of SDMs, gene flow tests of northern lineages, and the BayesAss directionality assessments of *P. keeni* are all consistent with the hypothesis that glacial-interglacial cycling over the past 300 ka initiated diversification of three distinctive clades that are found in Yukon today. We suggest that these clades emerged during their long-term separation in the three major geographical regions detected as having high potential for glacial persistence within the *Peromyscus* complex: (1) Southern (south of the

Table 2 Cyt *b* and multilocus divergence date estimates for North American *Peromyscus* sp., *P. keeni*, and *P. maniculatus*.

	cyt *b*			multilocus		
Lineage	95% HPD lower	median	95% HPD upper	95% HPD lower	mean	95% HPD upper
Peromyscus sp./*P. keeni*	–	–	–	124,200	159,600	205,000
Peromyscus sp.	175,200	282,200	414,100	59,500	87,200	118,300
P. keeni	199,900	276,700	377,700	98,700	126,300	153,400
P. maniculatus - West	217,700	313,600	435,800	–	–	–
BC/YT	99,600	145,900	205,600	41,800	68,800	102,400
P. maniculatus - East	176,500	275,900	390,900	–	–	–
P. maniculatus - East - a	53,800	124,200	203,900	–	–	–
P. maniculatus - East - b	71,500	125,200	200,900	–	–	–
P. maniculatus - East - c	34,300	92,800	173,800	–	–	–
P. maniculatus - South	27,900	91,200	201,400	–	–	–
P. maniculatus - Southwest	117,000	243,100	382,400	–	–	–

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Table 3 Recent historical migration rates under three models of hypothesized migration based on potential refugial locations for *Peromyscus keeni*. 1) Southern coastal refugium: Washington versus the remaining range, 2) either Southern or Northern coastal island refugium: Southern (southern British Columbia, Vancouver Island and Washington) versus Northern (northern British Columbia, Yukon and Alaska), and 3) Southeast Alaska coastal refugium: Southeast Alaskan islands versus all mainland populations. Non-migrants within each population are indicated in bold along the diagonal. Values are the proportion of migrant genes donated from source populations (columns) into sink populations (rows).

	Migration rates into…					
From…	NonWA	WA	North	South	SE Islands	Mainland
NonWA	**0.9984**	0.1776	–	–	–	–
WA	0.0016	**0.8224**	–	–	–	–
North	–	–	**0.9984**	0.1152	–	–
South	–	–	0.0016	**0.8848**	–	–
SE Islands	–	–	–	–	**0.9981**	0.0049
Mainland	–	–	–	–	0.0019	**0.9951**

continental ice sheets) for *P. maniculatus*, (2) Coastal (west of the ice sheets) for *P. keeni*, and (3) Northern/Beringia (north of the ice sheets) for *Peromyscus* sp. All *P. maniculatus* lineages show signs of stable populations during the LGM, with the addition of post-glacial expansion in the Western clade. Multiple lineages within each clade of southern *P. maniculatus* suggest multiple regions of incipient diversification distributed across the United States, south of the glacial extent, but a clear picture of structure in the *P. maniculatus* complex awaits more extensive sampling of geography and genomes for this widespread North American taxon.

Peromyscus sp., although currently occupying a limited range, most likely persisted in eastern Beringia during the confluence of the Laurentide and Cordilleran ice sheets in central Yukon and subsequently expanded southward into south-western Yukon. Fossil *Peromyscus* from central Yukon date to the LIG (Fig. 1; G.D. Zazula, pers. comm.; Storer, 2003). We predict that *Peromyscus* fossils dating to the LGM will be found in other regions of Yukon and east-central Alaska that remained ice-free.

Contemporary SDMs identify interior regions as optimal environmental conditions for *Peromyscus* sp., coastal regions for *P. keeni,* and non-montane continental areas for *P. maniculatus* West. High niche overlap may be influenced by methods based on raw output models that include areas of low suitability, combined with limited sampling for *Peromyscus* sp. and very broad sampling for *P. maniculatus* West. Although there is niche overlap amongst lineages, maintenance of genetic independence supports their long-term segregation, and may indicate that these species are differentially adapted.

Although other small mammal species (e.g., *Microtus longicaudus* and *Sorex monticolus*) show parapatric contact between divergent mtDNA lineages west of the Coast Range in northern Southeast Alaska (Conroy & Cook, 2000; Demboski & Cook, 2001; Sawyer, 2014; Sawyer & Cook, 2016), all clades of *Peromyscus* are geographically proximal only in Yukon, east of the Coast Range (Fig. 1) and to date no localities have been identified with more than a single species of *Peromyscus* (Fig. 1b). We hypothesize, however, that these species may be in sympatry in south-western Yukon, where all three occur. *Peromyscus keeni* and *P. maniculatus* extend south into British Columbia and Washington (Fig. 1; Zheng *et al.*, 2003), but *P. maniculatus* is only found east of the Coast Range, whilst *P. keeni* also occurs farther west along the coast. The two isolated populations of *P. maniculatus* documented in Alaska (i.e., Copper River Basin and Shemya Island in the Aleutian Chain) are considered accidental introductions (MacDonald & Cook, 2009; MacDonald *et al.*, 2009).

Our ability to detect contact zones and refugia are essential to understanding the dynamic Late Quaternary biogeography of high latitudes (Ashcroft, 2010; Stewart *et al.*, 2010; Dawson *et al.*, 2014) as well as contemporary patterns of geographical variation. *Peromyscus keeni* occupied coastal refugia throughout glacial cycles, but now ranges from Washington to south-western Yukon. High levels of differentiation of *P. keeni* populations of Southeast Alaska (Lucid & Cook, 2004) are a result of persistence in a refugium or series of refugia in the AA during the LGM followed by isolation and subsequent differentiation on individual islands. Peromyscine fossils recovered from karst caves (T.H. Heaton pers. comm.; Heaton *et al.*, 2003; Heaton & Grady, 2007) may support long-term occupation of this coastal region before the LGM, but those fossils are yet to be dated. Low genetic diversity throughout the southern portion of the range of *P. keeni* contrasts with greater structure in the north (i.e., AA) and may reflect both persistence in the coastal refugia and subsequent population level differentiation as a result of the highly fragmented landscape of Southeast Alaska. Additionally, high *Hd* for cyt *b* may reflect the smaller effective population size of mitochondrial loci coupled with a fragmented distribution with limited contemporary connectivity across the islands of the AA.

We explored the direction of gene flow across the entire range of *P. keeni* by including all previously published mtDNA sequences for the species. Zheng *et al.* (2003) concluded that *P. keeni* persisted in southern coastal refugia near Vancouver Island; however, their sampling of northern regions was limited. Our study increased northern representation and we found substantial support for the southward movement from north coastal refugia. Lack of gene flow from the AA populations onto the mainland reflects the strength of contemporary oceanic barriers to movement, as also reflected in the low levels of inter-island exchange. Consistent with a number of other north-western species (Cook & MacDonald, 2013), and given the highly structured mtDNA tree, divergence dates, possible fossil evidence and directionality tests of gene flow, *P. keeni* likely persisted in coastal refugia in or near Southeast Alaska (and perhaps Haida Gwaii) throughout the Pleistocene glacial cycles, as proposed by Lucid & Cook (2004), but likely did not persist

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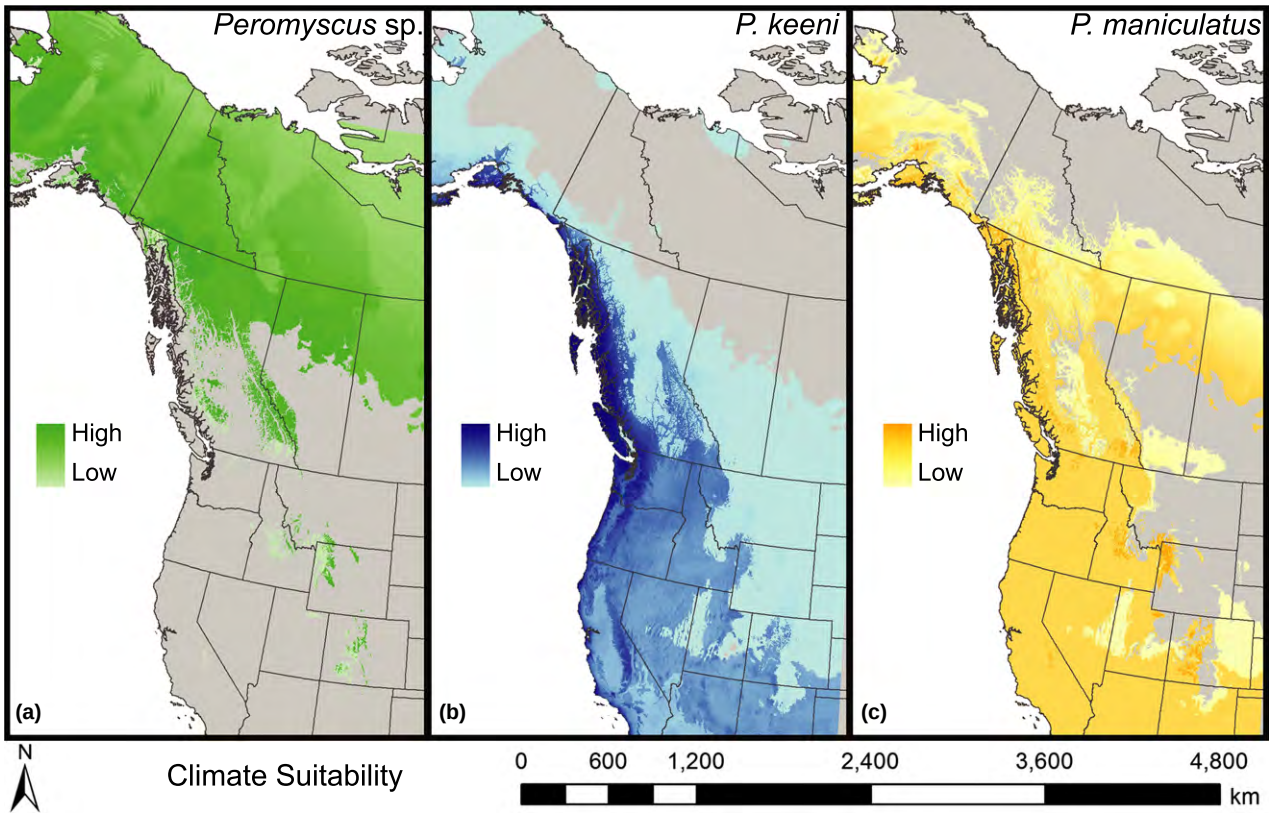

Figure 4 Ecological niche/SDM habitat suitability within western North America for (a) *Peromyscus* sp., (b) *P. keeni*, and (c) *P. maniculatus* - West with low habitat suitability at the minimum median threshold values over all replicates.

on Vancouver Island as proposed by Zheng *et al.* (2003), or solely on Haida Gwaii as proposed by Walker (2005). Still, future work should focus on refining the number of coastal refugia, their location (northern AA, southern AA, or Haida Gwaii), and their contribution to extant diversity on the islands and eastward into the continent.

Hibbard (1968) noted that fossil records for *Peromyscus* are scant and suggests the *P. maniculatus* group represents a late Pleistocene radiation. The location of contact of southern (*P. maniculatus*), coastal (*P. keeni*) and northern (*Peromyscus* sp.) refugial populations (i.e., south-central Yukon) is unusual for North American mammals, especially for a species group with such a broad geographical range (e.g., Swenson & Howard, 2005; Shafer *et al.*, 2010). Within Yukon, higher estimates of gene flow are likely the result of historical exchange rather than contemporary gene flow, given the support for distinct clades in the multilocus analysis. Higher estimates between *P. keeni* and *Peromyscus* sp. may result from historical proximity or incomplete lineage sorting. However, our data suggest the limited gene flow between the two, with levels of mtDNA exchange (the proportion of migrant genes donated from source populations; Sawyer, 2014) falling between typical intraspecific (0.035) and interspecific (0.10) ranges for delineating mammalian species (Bradley & Baker, 2001), but with nuclear variation potentially reflecting incipient speciation (e.g., Ross *et al.*, 2010; Nakajima *et al.*, 2012). More intensive geographical sampling of these deermice clades in southern Yukon and northern British Columbia will refine their distributions and help explore the dynamics of potential contact.

As currently understood, the newly detected *Peromyscus* sp. in north-western North America is limited in distribution to Yukon and likely persisted in glacial refugium nearby during the LGM, whilst *P. keeni* is primarily restricted to the islands and coast of the Pacific although populations have been detected east of the Coast Range. With greater sampling intensity, a comprehensive understanding of the biographical history and geographical structure within *P. maniculatus* and its close allies in the Pacific Northwest is now beginning to come into view.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1 Specimens examined.
Appendix S2 Dated Bayesian cyt *b* trees.
Appendix S3 Measures of niche overlap.

BIOSKETCH

Yadéeh E. Sawyer is interested in the effects of historical climate on contemporary small mammals, particularly in the high latitude islands of Southeast Alaska. This research was part of the doctoral dissertation of Y.E.S.

Author contributions: Y.E.S and J.A.C. developed the ideas; S.O.M., J.A.C, and T.S.J. collected the specimens; Y.E.S. collected the genetic data in the laboratory of J.A.C; Y.E.S. analysed the data; and Y.E.S., S.O.M., M.J.F., T.S.J. and J.A.C contributed to the writing.

Editor: Şerban Procheş

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ORGANIZED VILLAGE OF SAXMAN
SAXMAN I.R.A. COUNCIL
ROUTE 2, BOX 2 – SAXMAN, KETCHIKAN, ALASKA 99901 · FAX: (907) 247-2504 · PHONE (907) 247-2502

RESOLUTION #2018-10-223

A RESOLUTION BY THE ORGANIZED VILLAGE OF SAXMAN, SAXMAN I.R.A. COUNCIL TO AUTHORIZE TRIBAL SUPPORT FOR APPLICATION OF NATIONAL ROADLESS RULE ON THE TONGASS NATIONAL FOREST and TO AUTHORIZE STRONG SUPPORT FOR LASTING PROTECTION OF THE ROADLESS RULE.

WHEREAS, the Organized Village of Saxman (OVS) is a duly constituted federally recognized Indian Tribe organized pursuant to the authority of the United States Congress by the Indian Reorganization Act, and such legislation of June 8, 1934, whereby the Saxman I.RA. Council is the governing body as authorized by the Organized Village of Saxman Constitution and By-laws approved on October 18, 1940 by the Secretary of Interior, and ratified on January 14, 1941; and

WHEREAS, the Organized Village of Saxman possesses all powers and responsibilities inherent in a sovereign government and has the authority to represent and act in all matters that concern the health, education, and welfare of the Native people who reside in the Village of Saxman; and

WHEREAS, the Constitution and By-Laws of OVS empower the Saxman I.R.A. Council "to aid needy members and protect the general welfare and security of the Village," and one of the Tribe's highest priorities is to protect customary and traditional hunting, fishing and gathering areas and uses; and

WHEREAS, protection of the inherent right to harvest and use traditional and customary foods requires careful cultural stewardship and protection of the environmental and natural resources; and

WHEREAS, the care of the lands now classified as "inventoried roadless areas" in the Tongass National Forest stretches for millennia; and

WHEREAS, these lands not only provide Alaska Native people with food, they essentially define who we are and where we come from; and

WHEREAS, inventoried roadless areas contain many sacred sites used for spiritual and religious practices and other customary uses and activities; and

WHEREAS, inventoried roadless areas conserve natural diversity, serve as a bulwark against the spread of invasive species, protect healthy watersheds ensuring clean drinking water supply, and help ensure the continued protection of indigenous fish and wildlife habitat the social, nutritional, and ecological values; and

WHEREAS, the Tongass National Forest represents one of the highest carbon stores in the world and the conservation of intact inventoried roadless areas on the Tongass is essential for maintaining America's resilience and slowing down climate change throughout the world; and

WHEREAS, the Roadless Rule prevents the disturbance of soils and wasteful construction of damaging roads in inventoried roadless areas; and

WHEREAS, according to the State of Alaska's own economic experts, Tongass timber is uncompetitive because of permanent and fundamental changes in global timber markets, high labor costs, distance from markets, and less expensive substitutes; and

WHEREAS, the Tongass timber industry represents less than one percent of today's jobs and earnings in Southeast Alaska; and

WHEREAS, there are over 5,000 miles of roads already crisscrossing the Tongass National Forest, fragmenting valuable wildlife habitat, threatening salmon by blocking fish passage, and serving as the primary source of sediment into fish streams; and

WHEREAS, spending millions of taxpayer dollars to build roads in inventoried Tongass roadless areas makes no economic sense, particularly given the agency's enormous road maintenance backlog; and

WHEREAS, at hearings held across Southeast Alaska in 2000 on the proposed Roadless Rule, nearly 60 percent of the Southeast Alaskans supported including the Tongass National Forest in the final roadless rule; and

WHEREAS, after the hearing held in Ketchikan during the summer of 2002, the draft supplemental environmental impact prepared to evaluate recommendations for designating additional inventoried roadless areas on the Tongass as "Wilderness", the *Ketchikan Daily News* reported that roughly 85 percent of the public who testified supported more "Wilderness";

WHEREAS, the State of Alaska petitioned the United States Department of Agriculture (USDA) to exempt Tongass inventoried roadless areas from the Roadless Rule on January 19, 2018;

WHEREAS, for all the above reasons, the State's petition severely mischaracterizes the actual extent and impacts of the Roadless Rule on Southeast Alaska; and

WHEREAS, the State's petition ignores the fact that the USDA narrowly tailored the Roadless Rule to limit only two activities in roadless areas, road construction and commercial logging; and

WHEREAS, the State of Alaska's petition ignores the Rule's established exceptions, including Federal Aid Highway projects connecting communities, access to mining claims, and logging incidental to otherwise permitted activities, including utility corridors and hydropower projects; and

WHEREAS, on August 2, 2018, the Forest Service signed a Memorandum of Understanding (MOU) with the State of Alaska to develop an Alaska-specific Roadless Rule that addresses management of inventoried roadless areas on the Tongass National Forest; and

WHEREAS, three days before the MOU was signed and six months after the State filed its petition, the Forest Service informed OVS by a letter dated 30 July 2018 that the U.S. Secretary of Agriculture Perdue and State of Alaska Governor Walker had reached an agreement to prepare an Alaska-specific rule that would replace the Roadless Rule and "provide for activities needed to further the State of Alaska's economic development while conserving roadless areas for future generations;" and

WHEREAS, the July 30th letter served as an invitation from Acting Regional Forester, David E. Schmid to a "Tribal Leader" inviting "government-to-government consultation in advance of a formal public comment period and an opportunity for your Tribe to participate as a cooperating agency", because of our "expertise on subsistence and potential impacts to specific communities within Alaska" during preparation

of an environmental impact statement (EIS) to evaluate the proposed Alaska-specific Roadless Rule for the Tongass National Forest; and

WHEREAS, the U.S. Department of Agriculture, which includes the Forest Service, published a *Notice of Intent* (NOI) published on August 30, 2018 announcing an intent to prepare an environmental impact statement (EIS) and initiate a public rulemaking process; and

WHEREAS, the joint announcement issued by the Forest Service when the MOU was signed promises to leave unaffected Tongass lands designated "Wilderness" by Congress, but no mention is made of the fate of nearly 900,000 acres of Legislated LUD II lands designated for perpetual protection from logging and roadbuilding by Congress in the 1990 *Tongass Timber Reform Act* and the 2014 *Sealaska Lands Bill*; and

WHEREAS, any rule that weakens or eliminates Roadless Rule protections in what became Inventoried Roadless Areas of the Tongass National Forest will substantially affect the existing 2016 Tongass Land Management Plan Amendment; and

WHEREAS, the 2016 Plan Amendment excluded all roadless areas from the available timber base, the agency's failure to consult and coordinate forest planning with OVS will impair the Tribe's ability to fulfill its responsibility to "protect the general welfare and security" of tribal citizens; and

WHEREAS, the USDA and Forest Service entered into an MOU with the State of Alaska and issued the NOI for preparation of an EIS for an Alaska-specific Roadless Rule without prior consultation or collaboration with OVS; and

WHEREAS, one of the handouts provided by the Forest Service at the Ketchikan public scoping meeting on Monday, 17 of September 2018 identifies the responsibilities of the Tribe as a "cooperating agency," the Forest Service has not explained adequately why it failed to fulfill its' responsibilities to consult with the Tribe; and

WHEREAS, the State of Alaska resists all efforts to develop and work in a government to government relationship with Tribes and did not consult with the OVS before filing its' petition with the USDA; and

WHEREAS, Governor Walker issued Administrative Order 299, establishing the Alaska Roadless Rule Citizen Advisory Committee (CAC) on September 5, 2018; and

WHEREAS, Alaska Governor Walker appointed 13 Alaskans to the CAC, including the Alaska State Forester, to advise the State of Alaska on the future management of inventoried roadless area in the Tongass National Forest; and

WHEREAS, the Governor appointed a single Alaska Native to represent all tribal perspectives for the seventeen federally-recognized Tribes of Alaska Natives in Southeast Alaska on the CAC, a gigantic and unrealistic burden for one person; and

WHEREAS, the only other Alaska Native on the CAC represents Sealaska Corporation and Sealaska is an Alaska Native for-profit Corporation established under the *Alaska Native Claims Settlement Act* is not a Tribe.

THEREFORE, BE IT RESOLVED, the Forest Service must initiate consultation, coordination and accommodation of tribal interests in any changes to TLMP connected with this rulemaking process; and

THEREFORE, BE IT FURTHER RESOLVED, given the serious and long-lasting Tribal implications from any reduction in current Roadless Rule protections, the Organized Village of Saxman strongly objects to the Forest Service's failure to consult with OVS before deciding to grant the State of Alaska's petition and begin a review under the *National Environmental Policy Act* and public rulemaking process; and

THEREFORE, BE IT FURTHER RESOLVED, the only changes to the Roadless Rule that OVS can support is an update to the inventory used to define inventoried roadless areas subject to the Rule on the Tongass to include approximately 350,000 acres excluded from the 1995 inventory used for developing the 2001 Roadless Rule, because the agency assumed approved logging development would occur – when it did not; and

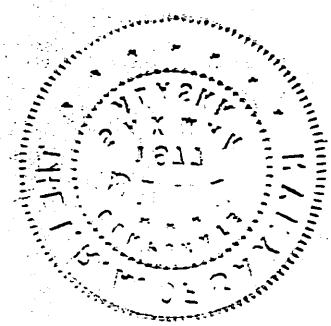
BE IT FINALLY RESOLVED, the Organized Village of Saxman strongly supports lasting protection for all inventoried roadless areas within the Tongass National Forest as provided in the Roadless Rule.

CERTIFICATION:
PASSED and **APPROVED** by a duly constituted quorum of the Saxman I.R.A. Council on October 10, 2018

_____ 10.11.18
Lee Wallace, Saxman I.R.A. Council President Date

ATTESTED:

_____ 10/11/18
Sylvia Banie, Saxman I.R.A. Council Vice President Date



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Population Diversity and the Portfolio Effect in An Exploited Species

Article *in* Nature · June 2010

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LETTERS

Population diversity and the portfolio effect in an exploited species

Daniel E. Schindler[1], Ray Hilborn[1], Brandon Chasco[1], Christopher P. Boatright[1], Thomas P. Quinn[1], Lauren A. Rogers[1] & Michael S. Webster[2]

One of the most pervasive themes in ecology is that biological diversity stabilizes ecosystem processes and the services they provide to society[1–4], a concept that has become a common argument for biodiversity conservation[5]. Species-rich communities are thought to produce more temporally stable ecosystem services because of the complementary or independent dynamics among species that perform similar ecosystem functions[6]. Such variance dampening within communities is referred to as a portfolio effect[7] and is analogous to the effects of asset diversity on the stability of financial portfolios[8]. In ecology, these arguments have focused on the effects of species diversity on ecosystem stability but have not considered the importance of biologically relevant diversity within individual species[9]. Current rates of population extirpation are probably at least three orders of magnitude higher than species extinction rates[10], so there is a pressing need to clarify how population and life history diversity affect the performance of individual species in providing important ecosystem services. Here we use five decades of data from *Oncorhynchus nerka* (sockeye salmon) in Bristol Bay, Alaska, to provide the first quantification of portfolio effects that derive from population and life history diversity in an important and heavily exploited species. Variability in annual Bristol Bay salmon returns is 2.2 times lower than it would be if the system consisted of a single homogenous population rather than the several hundred discrete populations it currently consists of. Furthermore, if it were a single homogeneous population, such increased variability would lead to ten times more frequent fisheries closures. Portfolio effects are also evident in watershed food webs, where they stabilize and extend predator access to salmon resources. Our results demonstrate the critical importance of maintaining population diversity for stabilizing ecosystem services and securing the economies and livelihoods that depend on them. The reliability of ecosystem services will erode faster than indicated by species loss alone.

The recent focus on ecosystem-based management of renewable resources emphasizes species interactions and how these are affected by human activities within exploited ecosystems. However, there is growing recognition that population diversity within exploited species can contribute to their long-term sustainability and should be incorporated more explicitly into management and conservation schemes[11,12]. For example, it has been argued[11] that population diversity reduced the temporal variability of sockeye salmon fisheries in Bristol Bay because of complementary dynamics in different components of the stock complex. Similar phenomena are now appreciated qualitatively in other marine ecosystems[12]. However, at present there are neither quantitative estimates of the strength of portfolio effects produced by population and life history diversity in exploited species, nor an objective assessment of the benefits of population diversity to human economies and ecosystem services in general.

From 1950 to 2008, sockeye salmon supported the most valuable fisheries in the United States (landed value, US$7,900,000,000), and 63% of the associated revenue came from Bristol Bay (see Supplementary Information for details). The total economic value of this fishery is considerably higher when considering the retail, cultural and recreational value of these fish. Income from sockeye salmon in Bristol Bay is the major source of personal income for most Bristol Bay communities, and landing taxes provide the major funding for local school districts. Thus, the interannual reliability of this fishery has critical and direct consequences for the livelihoods of people in this region.

Population diversity within the stock complex of Bristol Bay sockeye substantially reduces the interannual variability experienced by the commercial fishery, which intercepts sockeye salmon as they enter each of the nine major rivers of this region (Fig. 1a). Each river stock contains tens to hundreds of locally adapted populations distributed among tributaries and lakes (Fig. 1b and Supplementary Fig. 1). This remarkable diversity in sockeye reflects their ability to thrive in a wide range of habitat conditions, the reproductive isolation of populations by precise homing to natal spawning sites, and their capacity for microevolution[13]. Thus, the Bristol Bay sockeye fishery integrates across substantial population diversity both within and among watersheds.

Annual sockeye returns to the Bristol Bay stock complex were considerably less variable (coefficient of variation (standard deviation divided by mean), CV = 55%) than those observed for individual rivers (average CV = 77%; Fig. 1c) for 1962–2008. Annual returns to individual populations spawning in streams of the Wood River system, where long-term detailed population assessments are available (Fig. 1b), were more variable (average CV = 95%) than both the aggregate of these streams (CV = 67%) and the total returns to the Wood River (CV = 60%; Fig. 1c). Thus, annual sockeye returns become increasingly more stable across the complexity hierarchy ranging from individual spawning populations to stocks associated with the watersheds of major rivers and, eventually, to the regional stock complex of Bristol Bay.

The degree of temporal covariation among portfolio assets controls the strength of portfolio effects[8,14]; the buffering effects of asset diversity on variability of the aggregate portfolio become weaker as asset dynamics become more synchronous. Analysis of the covariation among river stocks and among stream populations (that is, the analogues of assets in an investment portfolio) showed that annual sockeye returns were only weakly synchronous (and some negatively correlated) both within and among the watersheds of Bristol Bay. This lack of synchrony among populations of Bristol Bay sockeye occurred despite many commonalities in their migration corridors, nursery habitats and seasonal timing of migrations between freshwater and marine environments. Furthermore, strong shifts in climatic conditions

[1]School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, Washington 98195-5020, USA. [2]The Gordon and Betty Moore Foundation, 1661 Page Mill Road, Palo Alto, California 94304, USA.

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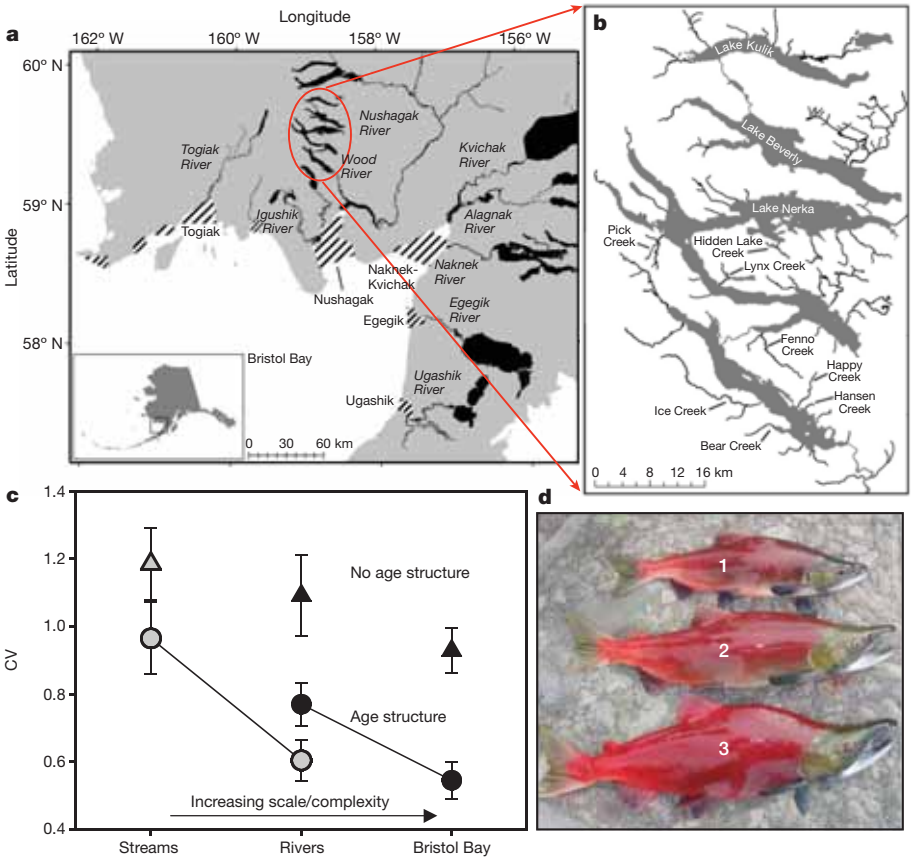

Figure 1 | Bristol Bay sockeye habitat and associated change in variability of returns at different spatial scales and levels of life history aggregation. **a**, Map of Bristol Bay, southwest Alaska. Sockeye salmon nursery lakes are shown in solid black. Fishing districts associated with major rivers are highlighted as striped areas. **b**, Map of the Wood River system showing streams supporting anadromous salmon populations. **c**, Interannual variability in total returns to sockeye populations and stocks at three spatial scales and two levels of life history aggregation. Grey symbols are for the Wood River, highlighting the watershed for which continuous long-term data on stream populations (1962–2007, $n = 8$) exist. Black symbols are for rivers (including the Wood River, $n = 8$) and the Bristol Bay aggregate (1958–2008). Circles show average variabilities for populations and stocks with their observed age composition, and triangles show average variabilities for the dominant age classes at each spatial scale. Error bars, 1 s.e. **d**, Three age classes of reproductively mature male sockeye salmon from the Wood River that have spent one, two or three years at sea, as indicated.

of the North Pacific Ocean during the past century[15,16] should also have induced synchrony in the population dynamics of the stock complex, but had little effect (Supplementary Fig. 2). Thus, the portfolio effects observed in Bristol Bay sockeye, both among major rivers and within individual watersheds, are derived from the weakly synchronous population dynamics among the components of this stock complex. If portfolio components in Bristol Bay fluctuated fully independently of one another, the expected CV would be only marginally lower (42% for rivers, 38% for Wood River tributary populations) than is currently observed (55% for rivers, 67% for tributary populations).

Life history diversity further buffers the variability of the sockeye stock complex. Most Bristol Bay sockeye spend one to two years rearing in fresh water and one to three years in the ocean as they complete their life cycles (Fig. 1d). This staggered age structure reduces variation in recruitment because it reduces the probability that all individuals in a cohort of siblings will encounter unfavourable environmental conditions over the course of the life cycle. To assess the effect of age structure diversity on variability, we compared the CV of total annual returns (above) with the CV observed within the two dominant age classes at each level of spatial aggregation considered earlier (Supplementary Fig. 3). The CVs of the dominant age classes in stream populations, river stocks and the Bristol Bay stock complex were respectively 44%, 42% and 69% higher than the variabilities observed at these spatial scales for the diversified population age structure (Fig. 1c). In sum, if the dynamics of Bristol Bay sockeye returns were characterized by the most simplified spatial and life history portfolio (that is, dominant age classes in the average stream population), they would be about 2.2 times more temporally variable (CV = 119%) than is currently observed for the Bristol Bay stock complex with its full complement of population and life history diversity.

To illustrate the value to commercial fisheries of population and life history diversity in Bristol Bay sockeye, we considered alternative hypothetical stocks characterized by the same long-term average return (30,000,000 fish) but with different interannual CVs. Furthermore, we assumed that fishery management would resemble the current system, in which the management goal is to allow approximately 10,000,000 fish onto the spawning grounds per year; returns in excess of 10,000,000 are harvested, and no fishing is allowed in years when fewer than 10,000,000 sockeye return. Given the current variability of the Bristol Bay stock complex, this picture translates into a complete fishery closure less than four times per century (Fig. 2). If Bristol Bay sockeye lacked the dampening effects population and life history diversity provide, complete fishery closures would occur every two to three years (Fig. 2). Thus, the net result of losing population and life history diversity could be a tenfold increase in the frequency of fishery closures, generating considerable hardship for people who rely on consistent annual returns for their livelihoods. A full assessment of the economic implications of such increased interannual variability resulting from loss of population and life history diversity would be valuable, but the necessary livelihood and economic data are lacking at present.

In addition to sustaining a valuable marine fishery, sockeye also support a diverse array of well-documented ecosystem processes and services in the watersheds where they spawn[17,18] (Supplementary

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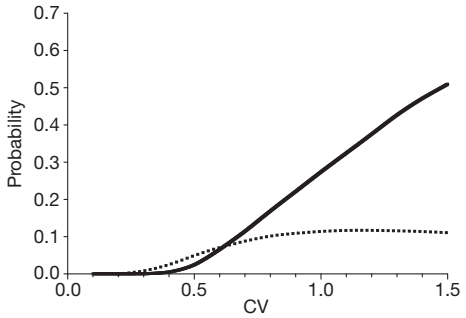

Figure 2 | Effect of interannual variability on the probability of fishery closures or capacity-swamping returns. Probability of total annual return being less than 10,000,000 (solid line) or greater than 60,000,000 (dotted line) as a function of the coefficient of variation in the overall distribution of returns. No fishing is allowed when total returns are less than about 10,000,000. Returns in excess of 60,000,000 swamp the capacity of the fishing fleet and processing industry to capture their allocation of the resource. Stock abundances were assumed to be characterized by log-normal distributions. Current Bristol Bay returns have a CV of about 0.55 and the simplest component of the stock dynamics is about 1.2.

Information). Sockeye release substantial quantities of productivity-limiting nutrients following their post-spawning death[19], and are the dominant food source for a community of mobile predators and scavengers in freshwater and terrestrial ecosystems. These species perform important ecosystem functions such as dispersing salmon-derived nutrients from spawning sites to the broader landscape[20,21]. Like commercial fisheries, many of these consumers are mobile and can capitalize on spatial variation in sockeye resources associated with the dynamics of individual populations within each river system. Using data on the number of spawning fish observed on the spawning grounds (the 'escapement'), the average CV observed for streams was 82% whereas that for their aggregate was 46% and that for the entire Wood River was 50%. Thus, consumers able to capitalize on high-density sockeye populations experience substantially less interannual variation in salmon resources than they would if they focused on individual stream populations or if population dynamics within the stock were highly synchronous.

The life history diversity observed in the seasonal timing of migration and spawning among populations further enhances many ecosystem services by extending the seasonal availability of salmon resources to the fishery and watershed food webs (Fig. 3). For example, in a typical commercial fishing season 90% of the catch is taken in about 16 days, yet the midpoints of sockeye migration to the respective fishing districts vary over a range of about 13 days (Fig. 3a). This variation in migration timing allows the fishing fleet to assess relative abundance of sockeye among districts and redirect effort to capture fish from multiple districts within a season. If seasonal migration timing were more synchronous among rivers, the window of opportunity to capture sockeye would be more constrained and the capture and processing fleet more easily saturated at the peak of the run. Seasonal access to sockeye by mobile predators is similarly extended because of staggered spawn timing among tributary and lake populations (Fig. 3b and Supplementary Fig. 3). Most sockeye populations are vulnerable to predators and scavengers in individual spawning habitats for approximately one month each year. However, salmon are present for over 2.5 months in spawning habitats throughout the Wood River watershed (Fig. 3b), owing to variation in the spawn timing among populations. Thus, watershed consumers of salmon and the ecosystem services they provide (for example trout fishing and wildlife viewing) also benefit from the variation in spawn timing, which represents one of many dimensions of life history variation in this species[13].

Although most large-scale fisheries probably integrate across considerable intraspecific diversity in a manner similar to that described here, this 'stock structure' is usually ignored by management focused

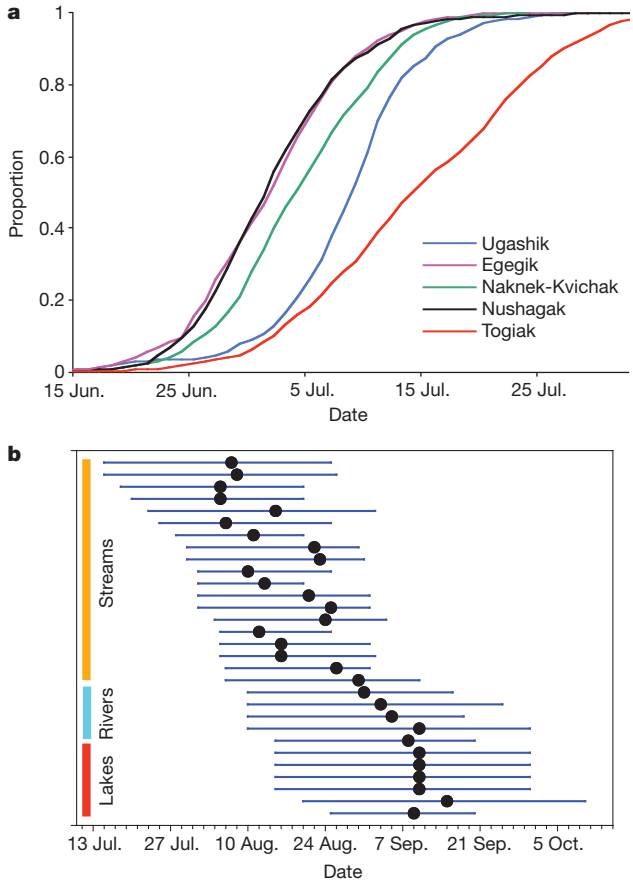

Figure 3 | Annual run timing to fishing districts and streams. a, Cumulative returns (catch plus escapement) to each of the major fishing districts in Bristol Bay for 2000–2007. The Bristol Bay fishery can currently process about 2,000,000 fish per day; on days with total returns above this level, the industry cannot capture their allocation of the resource. Between 1978 and 2007, the daily catch plus escapement was >2,000,000 fish on about seven days per season, on average. However, if all the fish had arrived at the fishing grounds with exactly the same timing, as determined by the distribution observed in any single fishing district in a given year, the length of the peak fishing season would have been reduced on average by 20% (range, 8–34%). **b**, Comparison of the dates of occupancy (dot, peak; line, occupancy period) in spawning habitats where sockeye salmon are available to predators and scavengers for 30 populations in the Wood River system (Supplementary Fig. 1).

on numerically dominant stock components[12]. Variation in the population dynamics of Bristol Bay sockeye is easy to monitor because of spatial separation among stock components resulting from the homing tendencies within populations. However, similar population diversity, although more cryptic, may exist and be equally important in other species[22], a possibility supported by the growing recognition of homing tendencies in marine and freshwater fish stocks[23,24]. There is no reason to believe that population and life history diversity are any less important in other aquatic or terrestrial species that are focuses of exploitation or conservation.

The portfolio effects in the Bristol Bay sockeye stock complex are a characteristic of a landscape with a largely undisturbed habitat, natural hydrologic regimes and neither invasive species nor artificial propagation of salmon in hatcheries, combined with sustainable fishery exploitation. In contrast, in the southern end of their range, Pacific salmon populations have declined substantially owing to the cumulative impacts of heavy exploitation, habitat loss, climate change, hatchery dependence and hydropower development. Recent assessments show that 29% of 1,400 populations of Pacific salmon in the US Pacific Northwest and California have been extirpated since European contact[25]. What is underappreciated is that extant stocks in highly

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affected watersheds have also lost some of the stabilizing portfolio effects that we observe in Bristol Bay[26,27].

Although ecosystem management schemes commonly map the habitat requirements of individual species, it is rare to consider the heterogeneity and disturbance regimes that maintain population and life history diversity in ecosystems. In the case of fisheries management, minimizing the homogenizing effects of hatcheries on genetic diversity and protection of weak stocks from overharvesting in mixed stock fisheries will be required to maintain the diversity that stabilizes variance in returns. Without this broader framework for conserving the roles of individual species, the resilience biodiversity provides to ecosystems[28] will deteriorate well before individual species are extirpated.

METHODS SUMMARY

Annual sockeye escapements to rivers were enumerated visually from towers on each of the Bristol Bay rivers by the Alaska Department of Fish and Game[29]. Age composition of sockeye was estimated by subsampling approximately 50,000 fish from the fisheries and the escapement towers in each year. Total returns to each river were calculated as the sum of fisheries catch and the escapement to the spawning grounds. In fishing districts that capture fish from neighbouring rivers, age composition comparisons between the fishery catch and the escapement towers was used to assign harvested fish to the total annual return to each river[29]. Stream-spawning populations of sockeye salmon in the Wood River system were monitored by two to four people who surveyed the entire extent of habitat suitable for sockeye spawning at least once per year at the peak of spawning activity. Otoliths were sampled annually from up to 220 fish from each steam to determine the age composition of the escapement. The total stream production for eight streams was calculated by accounting for the age- and year-specific vulnerabilities to the fishery and then adding estimated fishery interceptions back to the stream-spawning populations on the basis of the stream age composition in each year[30]. Interannual variability was calculated as the CV for all situations considered.

Full Methods and any associated references are available in the online version of the paper at www.nature.com/nature.

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Supplementary Information is linked to the online version of the paper at www.nature.com/nature.

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METHODS

River escapements were estimated by visual counts from towers located on either side of each of the Bristol Bay rivers by the Alaska Department of Fish and Game[29]. Migrating sockeye were counted for 20 min each hour, split equally between the two sides of each river, and these figures were extrapolated into daily escapement estimates. Nine major rivers contribute to the Bristol Bay fishery. For the analyses in this paper, we have not included the populations in the Nushagak River, as these have only been enumerated for the past two decades. Ages (numbers of years in fresh water and in the ocean) of fish were determined by visual examination of scales or otoliths sampled in the escapement and in the fishery catches.

Stream-spawning populations of sockeye salmon have been monitored by the University of Washington since 1956 throughout the Wood River system. Stream surveys were conducted by two to four people who walked the entire extent of habitat suitable for sockeye spawning at least once per year at the peak of spawning activity, counting the live and dead sockeye. Otoliths were sampled annually from up to 220 fish from each steam to determine the age composition of the returns. The total stream production for eight streams was calculated by accounting for the age- and year-specific vulnerabilities to the fishery on the basis of samples collected in the fishery, and then adding estimated fishery interceptions back to the stream-spawning populations on the basis of the stream age composition in each year[30].

The interannual variability in total returns to Bristol Bay was compared with the variability observed in the total returns to each of the major rivers. The variability in the annual returns to each of the eight streams in the Wood River for which we had detailed age composition data, which could be used to apportion fishery catches to total annual returns, was compared to the interannual variability observed in total returns to the Wood River system as a whole. When considering services provided by sockeye in freshwater ecosystems, we assessed variability only for sockeye abundance in the spawning grounds for the eight stream populations (that is, not including fishery interceptions).

We calculated covariations among the numbers of sockeye that returned to each of the rivers or streams (Supplementary Fig. 2) as the Pearson correlation among all pairwise combinations of stocks or populations with a minimum of ten years of concurrent data. Because the time series were often positively autocorrelated, we used the method of ref. 31 to adjust the degrees of freedom in tests of significance for each pairwise correlation. Tests of statistical significance were two-tailed, with $\alpha = 0.05$.

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SCIENTISTS CALL ON THE FOREST SERVICE TO UPHOLD THE NATIONAL ROADLESS AREA RULE THAT PROTECTS OVER 9 MILLION ACRES ON THE TONGASS NATIONAL FOREST, ONE OF THE WORLD'S LAST INTACT TEMPERATE RAINFORESTS

As scientists with expertise in conservation science, climate change, wildlife and fisheries policy, and economics, we urge the Forest Service to uphold the National Roadless Area Conservation Rule on the Tongass National Forest in southeast Alaska. The Forest Service is proposing a new Alaska-specific roadless rule that would open all 9.4 million acres of the Tongass forest's roadless areas to development. Such actions will adversely impact the region's robust recreation and fishing economy and displace traditional subsistence users who rely on verdant temperate rainforests remaining intact. At a time of unprecedented climate change and in the face of a rapidly approaching global biodiversity crisis[1], protecting carbon- and wildlife-rich places like the Tongass forest has never been more urgent.

The landmark National Roadless Conservation Rule enacted in 2001 protects 58.5 million acres of the nation's most intact forest landscapes, including the Tongass forest. As the premier conservation achievement of its time, the Roadless Rule is predicated on years of careful deliberation, unprecedented numbers of public meetings, more than 1 million supportive public comments, and the backing of hundreds of scientist signatories. Overwhelming public support for roadless protections was demonstrated again in recent public meetings held by the Forest Service regarding the Alaska-specific rule change.

Alaskans and the nation are blessed with some of the wildest, most biologically prolific temperate rainforests on Earth[2]. Nowhere else in America is this more evident than on the Tongass, the crown jewel of the national forest system. The Tongass contains ~16% of the national roadless acreage and at least 8% of the nation's total forest carbon stores[3]. Free of development, Tongass roadless areas allow all five species of Pacific salmon to replenish; deer, wolves, bears and other wildlife find sanctuary in them as well[2].

Alaska is experiencing the nation's fastest rate of climate change, 3-degree F warming since 1949[4]. This comes with severe long-term consequences already evident in melting glaciers and permafrost, coastal erosion, displaced Alaskan villages, and die-off of Alaska yellow cedar[5]. Roadless areas provide refuge for species experiencing more rapid climate change such as in the Alaska interior[6]. Opening roadless areas to development would emit much of the forest's stored carbon at a time when the world needs to drastically cut emissions[3,7].

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Building roads into an intact forest jump starts a death-by-thousand cuts scenario. Roads fragment wildlife habitat into small, isolated parcels that contribute to declining wildlife populations[8], as is evident for wolf and deer populations on nearby Prince of Wales Island. Roads and associated landslides have pervasive and lasting deleterious impacts on streams and fish habitats.

Wild places, like those protected by the Roadless Rule, also are the backbone of the southeast Alaska economy. According to Forest Service, many of Alaska's nearly 2 million annual visitors come to the Tongass to hunt, fish and recreate, while spending over $350 million. The Tongass produces ~40% of Alaska's commercial salmon fishery that was worth an estimated $414 million in 2015. The visitor industry alone contributes nearly 8000 jobs to the regional economy, while logging jobs (currently about 60) on the Tongass forest pale by comparison[9].

Logging in the Tongass is completely dependent on annual subsidies because Forest Service expenditures typically exceed timber revenues by over $20 million. Road construction costs at $250,000 per mile make it especially difficult to find timber sales that have positive appraisal values. The Forest Service goes so far as requiring taxpayers to pay for roads, rather than the timber companies; even then, the agency allows companies to export up to 100% of logs.

Although the Roadless Rule protects intact areas greater than 5,000 acres in extent, it has numerous allowances to include road connections between communities and other state highway projects, access to mining claims under the Mining Law of 1872, utility corridors, and hydropower projects. As of September 2019, the Forest Service reviewed and approved all 67 projects proposed within Alaska roadless areas, typically within a month of proposal submission.

Additionally, the Tongass Advisory Committee, made up of representatives of the State of Alaska, timber industry, conservation groups, and the regional Alaska Native corporation, unanimously agreed in 2016 that the Forest Service should protect roadless areas[10]. They also agreed that the agency should transition timber management out of old-growth logging and into previously logged, younger forests.

In closing, the Forest Service must recognize that efforts to undermine the Roadless Rule on the Tongass will only prove divisive and unnecessary. The Roadless Rule is working for Alaskans by supporting the regional economy, allowing the kinds of development that local people want, and holding together a globally important rainforest that is under enormous pressures from unprecedented climate change and the ever-expansive human ecological footprint.

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Sincerely (affiliations for identification purposes only),

Lead Signatures

Dominick A. DellaSala, Ph. D.
Chief Scientist
Geos Institute, Ashland, OR

Reed Noss, Ph. D.
Chief Scientist and Florida Inst. Cons. Science & Visiting Scholar, Nicholas School of Environment
Duke University, Orlando, FL.

Paul C. Paquet, Ph. D.
Professor Adjunct, Univ. of Victoria, BC
Canada & Raincoast Cons. Foundation

David S. Wilcove, Ph. D.
Prof., Evolutionary Biology/Public Affairs
Princeton University, NJ

William Ripple, Ph. D.
Distinguished Professor
Oregon State University, Corvallis, OR

John Terborg, Ph. D.
Emeritus Professor
Univ. of Florida, Gainesville, FL
James Cook University, Cairns, Australia

Ernie Niemi, M.S.
Economist
Natural Resource Economics
Eugene, OR

John Schoen, Ph. D.
Wildlife Ecologist
Anchorage, AK

Russell Lande, Ph. D.
Emeritus Professor
University California, San Diego, CA

Edward O. Wilson, Ph. D.
University Research Professor Emeritus
Harvard University

Thomas Lovejoy, Ph. D.
George Mason Universit
Washington, DC

Dennis Murphy, Ph. D.
Biology Department
University of Nevada, Reno, NV

Chris Maser, Ph. D.
Social-Environmental Sustainability
Corvallis, OR

Thomas Michael Power, Ph. D.
Professor Emeritus, University Montana
Power Consulting, Inc. Missoula

Stuart Pimm, Ph. D.
Professor, Conservation
Nicholas School of the Environment
Duke University, Durham, NC

Matt Kirchoff, M. S.
Retired Wildlife Biologist
Anchorage, AK

Barry Noon, Ph. D.
Emeritus Professor
Dept. Fish, Wildlife & Conservation Biol.
Colorado State University, Ft. Collins, CO

Steven R. Beissinger, Ph. D.
Professor of Conservation Biology
University of California, Berkeley, CA

Additional Signatories

Peter Abrams, Ph. D.
Professor Em. of Ecology & Evolutionary Bio.
University of Toronto
Victoria, Maryland

Peter Albers, Ph. D.
Retired USGS Research Wildlife Biologist
Traverse City, Michigan

A. Z. Andis Arietta, M.S.
Ph. D. Candidate
Yale University, School of Forestry and Env.
New Haven, Connecticut

William Armbruster, Ph. D.
Principal Research Scientist
University of Alaska
Fairbanks, Alaska

Jonathan Aurnou, Ph. D.
Professor of Planetary Physics
UCLA
Los Angeles, California

Peter Bahls, M.S.
Executive Director/Fish Biologist
Northwest Watershed Institute
Port Townsend, Washington

Carl Bailey, Ph. D.
Professor of Biology
New Mexico State University
Las Cruces, New Mexico

Rowan Baker, M.S.
Fisheries Biologist/Watershed Specialist
Retired
Portland, Oregon

William Baker, Ph. D.
Professor Emeritus
University of Wyoming
Laramie, Wyoming

Bruce G. Baldwin, Ph. D.
Professor of Integrative Biology
University of California
Berkeley, California

Mark Barath, M.S.
Retired scientist
U.S. EPA
Willow Grove, Pennsylvania

Jesse Barber, Ph. D.
Associate Professor
Boise State University
Boise, Idaho

Linda Sue Barnes, Ph. D.
Professor Emeritus of Biology
Methodist University
Fayetteville, North Carolina

Frank Barnwell, Ph. D.
Professor Emeritus
University of Minnesota-Twin Cities
Minneapolis, Minnesota

Constance Becker, Ph. D.
Director
Life Net Nature
Willcox, Arizona

Craig Benkman, Ph. D.
Professor
University of Wyoming
Laramie, Wyoming

Michael Bennett, Ph. D.
Professor of Neuroscience
Albert Einstein College of Medicine
Bronx, New York

David Berg, Ph. D.
Professor of Biology
Miami University
Oxford, Ohio

Linda Bernhardt, M.S.
Natural Resources Manager, retired
Talent, Oregon

Robert Beschta, Ph. D.
Professor Emeritus
Oregon State University
Corvallis, Oregon

Richard Bierregaard, Ph. D.
Research Associate
Academy of Natural Sci. of Drexel Univ.
Philadelphia, Pennsylvania

Scott Black, M.S.
Executive Director
Xerces Society for Invertebrate Conservation
Portland, Oregon

Brian Bodenbender, Ph. D.
Professor of Geology and Env. Science
Hope CollegeProfessor
Holland, Michigan

Brooke Boswell, M.S.
Research Program Manager
Northern Biobank Initiative
Edmonds, Washington

John Bowman, Ph. D.
Professor
Monash University
Melbourne, Australia

Dennis Bramble, Ph. D.
Professor Emeritus of Biology
Univerisity of Utah
Salt Lake City, Utah

Kristin Carden, J.D./Ph.D.
Oceans Program Scientist
Center for Biological Diversity
Bozeman, Montana

Gary Carnefix, M.S.
Retired
Carnefix Ecological Consulting
Missoula, Montana

Bobb Carson, Ph. D.
Professor Emeritus
Lehigh University
Bethlehem, Pennsylvania

Kai Chan, Ph. D.
Professor
IRES, University of British Columbia
Vancouver, British Columbia

F. Stuart Chapin III, Ph. D.
Professor Emeritus of Ecology
University of Alaska Fairbanks
Fairbanks, Alaska

Donald Charles, Ph. D.
Senior Scientist
Academy of Natural Sci. of Drexel Univ.
Philadelphia, Pennsylvania

Mike Cohen, Ph. D.
Professor of Biology
Sonoma State University
Rohnert Park, California

Phyllis Coley, Ph. D.
Distinguished Professor
University of Utah
Salt Lake City, Utah

Joseph Cook, Ph. D.
Regents Professor of Biology
University of New Mexico
Albuquerque, New Mexico

Tara Cornelisse, Ph. D.
Senior Scientist
Center for Biological Diversity
Portland, Oregon

Will Crampton, Ph. D.
Associate Professor
University of Central Florida
Orlando, Florida

Patrick Crist, Ph. D.
Principal
Broomfield, Colorado

Sam Davis, Ph. D.
Conservation Scientist
Dogwood Alliance
Asheville, North Carolina

Catherine De Rivera, Ph. D.
Professor of Env. Science & Management
Portland State University
Portland, Oregon

John DeCicco, Ph. D.
Research Professor
University of Michigan
Ann Arbor, Michigan

Terry Dickey, M.Ed.
Board Chair
Friends of Cascade-Siskiyou Nat'l Monument
Ashland, Oregon

Alan Dickman, Ph. D.
Professor Emeritus
University of Oregon
Eugene, Oregon

Andrew Dobson, Ph. D.
Professor
Princeton University
Princeton, New Jersey

Nathan Donley, Ph. D.
Senior Scientist
Center for Biological Diversity
Portland, Oregon

Craig Downer, M.S.
Wildlife Ecologist
Andean Tapir Fund
Minden, Nevada

Blake Downing, Ph. D. Candidate
Department of Plant and Microbial Biology, UC Berk
Berkeley, California

Peter Dunwiddie, Ph. D.
Affiliate Professor
University of Washington
Seattle, Washington

Katarina Eckerberg, Ph. D.
Professor
Ume University
Umeå, Sweden

Ginny Eckert, Ph. D.
Associate Professor
University of Alaska
Juneau, Alaska

Marianne Edain, B.A.
Restoration Ecologist
Frosty Hollow Ecological Restoration
Langley, Washington

Mark Egger, M.S.
Research Associate
WTU Herbarium, Burke Museum of Nat History
Seattle, Washington

Heather Erickson, Ph. D.
Research Ecologist
Consulting Research Ecology
Portland, Oregon

Jerry Estberg, Ph. D.
Professor Emeritus
University of San Diego
Port Angeles, Washington

Daniel Evans, Ph. D.
Environmental Scientist
Denver, Colorado

Jonathan Evans, Ph. D.
Professor of Biology
University of the South
Sewanee, Tennessee

Jules Evens, M.S.
Principal
Avocet Research Associates
Point Reyes Station, California

Sophia Ewens, Ph. D. Candidate
UC Berkeley
Berkeley, California

Daniel Feller, B.S.
Western Region Ecologist
Maryland Department of Natural Resources
Frostburg, Maryland

Elizabeth Figus, Ph. D.
Postdoctoral Researcher
University of Alaska Fairbanks
Juneau, Alaska

Doug Fischer, Ph. D.
Research Scholar
Ronin Institute
Santa Barbara, California

Daniel Fisher, Ph. D.
Professor of Earth and Env.l Sciences
University of Michigan
Ann Arbor, Michigan

Margaret Flaherty, MPT
Assistant Director of Rehabilitation Services
Berkeley, California

Thomas Fleischner, Ph. D.
Executive Director
Natural History Institute
Prescott, Arizona

Johannes Foufopoulos, Ph. D.
Associate Professor
University of Michigan
Ann Arbor, Michigan

Janet Franklin, Ph. D.
Professor
University of California
Riverside, California

Evan Frost, M.S.
Terrestrial Ecologist
Wildwood Consulting LLC
Ashland, Oregon

Robert Fuerstenberg, M.S.
Ecologist
Retired
Vashon, Washington

John Gatz, Ph. D.
Professor Emeritus of Zoology
Ohio Wesleyan University
Delaware, Ohio

Jennifer Gervais, Ph. D.
Wildlife Ecologist
Oregon Wildlife Institute
Corvallis, Oregon

Allen Gibbs, Ph. D.
Professor
University of Nevada
Las Vegas, Nevada

Elizabeth Glenn, Ph. D.
Biologist
Corvallis, Oregon

Scott Goetz, Ph. D.
Professor
Northern Arizona University
Flagstaff, Arizona

Robert Good, DVM, MS
Epidemiologist
USDA
Welsville, Kansas

David Gray, Ph. D.
Professor
California State University Northridge
Northridge, California

Steven Green, Ph. D.
Senior Professor Emeritus
University of Miami
Coral Gables, Florida

Gregory F. Grether, Ph. D.
Professor of Biology
University of California
Los Angeles, California

Robert Grumbine, Ph. D.
Senior Researcher
Kunming Institute of Botany
Bellingham, Washington

Leah Gulyas, B.S.
Graduate Student
University of California, Berkeley
Berkeley, California

Simon Gunner, M.S.
Botanist
Olofson Environmental, Inc.
Oakland, California

Paula Halupa, M.S.
Retired Fish and Wildlife Biologist
U.S. Fish and Wildlife Service (retired)
Fort Pierce, Florida

Cheryl Harding, Ph. D.
Professor Emeritus
CUNY
New York, New York

Cindy Haws, M.S.
Retired Wildlife Biologist
Umpqua Natural Leadership Science Hub
Myrtle Creek, Oregon

Betsy Herbert, Ph. D.
Free lance environmental writer
Betsyherbert.com
Corvallis, Oregon

Marissa Hill, M.S.
Senior Analyst
Toronto, Canada

Karen Holl, Ph. D.
Professor of Environmental Studies
University of California Santa Cruz
Felton, California

Richard T. Holmes, Ph. D.
Professor Emeritus of Biology
Dartmouth College
Hanover, New Hampshire

Elizabeth Horvath, M.S.
Associate Professor of Biology
Westmont College
Santa Barbara, California

Edward Huang, Ph. D.
Principal
California Institute of Env. Design & Mgmt.
Arcadia, California

Malorri Hughes, M.S.
Portland State University
Portland, Oregon

Malcolm Hunter, Ph. D.
Professor
University of Maine
Orono, Maine

Marc Imlay, Ph. D.
Natural Places Chair, Sierra Club
Bryans Road, Maryland

Karl Jarvis, Ph. D.
Lecturer
Southern Utah University
Cedar City, UT

Mitchell Johns, Ph. D.
Professor Emeritus Soil and Crop Science
California State University
Chico, California

Thomas L Johnson, Ph. D.
Retired
University of Mary Washington
Fredericksburg, Virginia

Russell Jones, Ph. D.
Professor Emeritus
University of California
Berkeley, California

Alan Journet, Ph. D.
Professor Emeritus
Southeast Missouri State University
Jacksonville, Oregon

Walter Judd, Ph. D.
Distinguished Professor Emeritus
University of Florida
Gainesville, Florida

Jacob Kann, Ph. D.
Aquatic Ecologist
Aquatic Ecosystem Sciences LLC
Ashland, Oregon

James Karr, Ph. D.
Professor Emeritus
University of Washington
Seattle, Washington

Ken Keefover-Ring, Ph. D.
Assistant Professor
Madison, Wisconsin

Bruce Kendall, Ph. D.
Professor
University of California, Santa Barbara
Santa Barbara, California

Eugene Kennedy, M.A.
Associate Faculty
Butte College
Oroville, California

Maya Khosla, M.S.
Senior Biologist and Toxicologist
S2S
Rohnert Park, California

Bruce Kirchoff, Ph. D.
Professor
University of North Carolina at Greensboro
Greensboro, North Carolina

Jason Koontz, Ph. D.
Professor of Biology and Env. Studies
Augustana College
Rock Island, Illinois

Fayette Krause, Ph. D.
Retired
Port Townsend, Washington

Rick Landenberger, Ph. D.
Science & Mgmt. Specialist and Assistant Prof
WVU, Dept. Of Geology and Geography
Morgantown, West Virginia

Kim Landsbergen, Ph. D.
Associate Professor
Antioch College
Yellow Springs, Ohio

Inger Marie Laursen, M.S.
Wildlife Biologist
Jkander@ucsc.edu
Watsonville, California

Beverly Law, Ph. D.
Prof. Global Change Biology & Terrestrial Sys.
Oregon State University
Corvallis, Oregon

Derek Lee, Ph. D.
Associate Research Professor
Penn State University
University Park, Pennsylvania

Peggy G. Lemaux, Ph. D.
Cooperative Extension Specialist
University of California, Berkeley
Berkeley, California

Gene Likens, Ph. D.
Distinguished Senior Scientist, Emeritus
Cary Institute of Ecosystem Studies
Clinton Corners, New York

Harvey Lillywhite, Ph. D.
Professor of Biology
University of Florida
Gainesville, Florida

Jay Lininger, M.S.
CEO & Principal Scientist
Pyrolysis LLC
Talent, Oregon

Brian Linkhart, Ph. D.
Professor
Colorado College
Colorado Springs, Colorado

Darvel Lloyd, M.A.
Retired
Portland, Oregon

Darryl Lloyd, M.S.
Author
Friends of Mount Adams
Hood River, Oregon

Andy MacKinnon, Ph. D.
Forest Ecologist
Simon Fraser University
Metchosin, Canada

Lucas Majure, Ph. D.
Herbarium Curator, Assistant Professor
Florida Museum of Natural History
Gainesville, Florida

Travis Marsico, Ph. D.
Professor
Arkansas State University
Jonesboro, Arkansas

Chris Maser, M.S.
Social-environmental Sustainability
Corvallis, Oregon

Kathleen McCarthy, M.S.
Landscape Restoration Project Manager
New York, New York

Dylan McClung, B.S.
Graduate Student
University of California, Berkeley
Berkeley, California

Carl McDaniel, Ph. D.
Professor Emeritus and Visiting Professor
Rensselaer and Oberlin College
Oberlin, Ohio

Daniel McGarvey, Ph. D.
Associate Professor of Environmental Studies
Virginia Commonwealth University
Richmond, Virginia

Gary Meffe, Ph. D.
Conservation Biologist, retired
Conservation Biologist, Textbook Author
Brandon, Vermont

Douglas Meikle, Ph. D.
Professor and Chair of Biology
Miami University
Oxford, Ohio

E. Charles Meslow, Ph. D.
Retired Wildlife Research Biologist
USFWS
Corvallis, Oregon

Ellen Moyer, Ph. D.
Principal
Greenviron,ent, LLC
Montgomery, Massachusetts

Megan Mueller, M.S.
Senior Conservation Biologist
Rocky Mountain Wild
Denver, Colorado

John Mull, Ph. D.
Professor of Zoology
Weber State University
Ogden, Utah

Pete Murphy, Ph. D.
Professor Emeritus
Michigan State University
East Lansing, Michigan

K. Greg Murray, Ph. D.
Professor of Biology
Hope College
Holland, Michigan

James Murray, Ph. D.
Professor Emeritus of Biology
University of Virginia
Charlottesville, Virginia

Philip Myers, Ph. D.
Professor Emeritus
University of Michigan
Ann Arbor, Michigan

Christopher Nagano, MES
Senior Scientist
Center for Biological Diversity
Portland, Oregon

Richard Nawa, M.A.
Staff Ecologist
Klamath Siskiyou Wildlands Center
Ashland, Oregon

Cara Nelson, Ph. D.
Professor
University of Montana
Missoula, Montana

Gretchen North, Ph. D.
Professor of Biology
Occidental College
Los Angeles, California

Richard Nyhof, Ph. D.
Professor Emeritus of Biology
Calvin University
Grand Rapids, Michigan

Philip Nyhus, Ph. D.
Associate Professor
Colby College
Waterville, Maine

Ewa Orlikowska, M.S.
Ph. D. Candidate
Swedish University of Ag. Sciences
Skinnskatteberg, Sweden

Steven Osofsky, DVM
Professor, Wildlife Health & Health Policy
Cornell University
Ithaca, New York

John Pagels, Ph. D.
Professor Emeritus
Virginia Commonwealth University
Chesterfield, Virginia

Daniel Papaj, Ph. D.
Professor
University of Arizona
Tucson, Arizona

Gustav Paulay, Ph. D.
Curator & Professor
University of Florida
Gainesville, Florida

Steve Paulsen, Ph. D.
Senior Research Scientist
Corvallis, Oregon

Michael Pelizzari, Ph. D.
Physicist, retired
Milpitas, California

Raimundas Petrokas, Ph. D.
Scientist
Institute of Forestry, Lithuanian Research Centre
Kaunas, Lithuania

Roger A Powell, Ph. D.
Professor Emeritus
North Carolina State University
Raleigh, North Carolina

Nancy Pullen, Ph. D.
Professor
Kennesaw State University
Kennesaw, Georgia

Robert Pyle, Ph. D.
Biologist and Writer
Independent
Gray's River, Washington

John Ratti, Ph. D.
Research Scientist, Retired
University of Idaho
Moscow, Idaho, Idaho

Ryan Rebozo, Ph. D.
Director of Conservation Science
Pinelands Preservation Alliance
Southampton, New Jersey

Fred M. Rhoades, Ph. D.
Biology Department Research Associate
Western Washington University
Bellingham, Washington

Jennifer Riddell, Ph. D.
Faculty
Mendocino College
Ukiah, California

John Robinson, Ph. D.
Chief Conservation Officer
Wildlife Conservation Society
Bronx, New York

Javier Rodriguez, Ph. D.
Professor
University of Nevada, Las Vegas
Las Vegas, Nevada

Garry Rogers, Ph. D.
President
Agua Fria Open Space Alliance, Inc.
Humboldt, Arizona

Dan Rosenberg, Ph. D.
Wildlife Ecologist
Oregon Wildlife Institute
Corvallis, Oregon

Don Ross, Ph. D.
Research Professor of Soils
University of Vermont
Burlington, Vermont

Amy Rossman, Ph. D.
Research Leader
USDA-ARS
Corvallis, Oregon

Matthew Rubino, M.S.
Research Scholar
North Carolina State University
Raleigh, North Carolina

Robin Salter, Ph. D.
Professor Emeritus
Oberlin College
Oberlin, Ohio

Melissa Savage, Ph. D.
Associate Professor Emeritus
University of California Los Angeles
Los Angeles, New Mexico

Carol Savonen, M.S.
Assoc prof emerita
Oregon State University
Corvallis, Oregon

Paul Schaeffer, Ph. D.
Associate Professor
Miami University
Oxford, Ohio

Charles Schelz, M.S.
Ecologist
Cascade-Siskiyou NM
Ashland, Oregon

Karl Schneider, M.S.
Regional ResearchSupervisor
State of Alaska Department of Fish and Game
Anchorage, Alaska

Brant Schumaker, DVM, MPVM, PhD
Laramie, Wyoming

Kathy Schwager, M.S.
Ecologist
Yaphank, New York
Will Sears, M.S.
Board of Directors
Lomakatsi restoration project
Ashland, Oregon

Steve Sheffield, Ph. D.
Professor of Biology
Crofton, Maryland

Janet Shellman Sherman, Ph. D.
Lecturer, Research Scientist, retired
Cornell University
Eastsound, Washington

Thomas Sherry, Ph. D.
Professor
Tulane University
New Orleans, Louisiana

Thomas D Sisk, Ph. D.
Olajos-Goslow Chair of Env. Science and Policy
Northern Arizona University
Flagstaff, Arizona

Diana Six, Ph. D.
Professor of Forest Entomology and Ecology
University of Montana
Missoula, Montana

James C Slater Slater, M.S.
Alternative Energy Engineer
Pelican, Alaska

Gar Smith, B.A.
Director, Academic Publishing, Inc.
Environmentliasts Against War.org
Berkeley, California

Douglas R Smith, M.F.A.
Professor Emeritus, retired
Yosemite Community College District, retired
Ashland, Oregon

Winston Smith, Ph. D.
Principal Research Scientist
Institute of Arctic Biology, University of Alaska
Juneau, Alaska

Jack Sobel, M.S.
President
Little Falls Watershed Alliance
Bethesda, Maryland

Trygve Steen, Ph. D.
Professor of Env. Science and Mgmt.
Portland State University, ESM dept.
Portland, Oregon

Bruce Stein, Ph. D.
Chief Scientist and Associate Vice President
National Wildlife Federation
Washington, DC, District of Columbia

Andrew Stephenson, Ph. D.
Distinguished Professor of Biology
Penn State University
University Park, Pennsylvania

Gwen Stone, M.S.
Cfo
After care Companions
Mission Viejo, California

Richard Strathmann, Ph. D.
Professor Emeritus
University of Washington
Friday Harbor, Washington

Michael Swift, Ph. D.
Assistant Professor Emeritus of Biology
St. Olaf College
Northfield, Minnesota

Stephen Tettelbach, Ph. D.
Professor Emeritus of Biology
Long Island University
Brookville, New York

Walter Tschinkel, Ph. D.
Professor Emeritus of Biology
Florida State University
Tallahassee, Florida

Anna Tyler, Ph. D.
Research Scientist
The Jackson Laboratory
Bar Harbor, Maine

Dean Urban, Ph. D.
Professor of Landscape Ecology
Duke University
Durham, North Carolina

Mike Vandeman, Ph. D.
Retired
Human-Free Habitat Association
San Ramon, California

John Vogel, Ph. D.
Adjunct Professor
University of Califronia, Berkeley
Berkeley, California

Marlene Wagner, M.S.
Ecologist, Ph. D. Candidate
Simon Fraser University
Petersburg, Alaska

Robert Wagner, Ph. D.
Ecologist
Quantitative Ecological Services, Inc.
Castle Rock, Colorado

David Wake, Ph. D.
Professor, Grad. School in Integrative Biology
University of California
Berkeley, California

Greg Walker, Ph. D.
Professor Emeritus
University of california, riverside
Riverside, California

Faith Walker, Ph. D.
Research Professor
Northern Arizona University
Flagstaff, Arizona

Don Waller, Ph. D.
Professor Emeritus
University of Wisconsin - Madison
Madison, Wisconsin

Bridget Watts, M.S.
Biologist
Borealis LLC
Arlington, Virginia

Frank Wegscheider, M.A.
Wildlife Biologist
Orange, California

Judith Weis, Ph. D.
Professor Emeritus
Rutgers University
New York, New York

Jeffery Werner, Ph. D.
Wildlife Ecologist, Provincial Government
BC FLNRORD
Prince George, British Columbia

Dave Werntz, M.S.
Science and Conservation Director
Conservation Northwest
Twisp, Washington

David Whitacre, Ph. D.
Biology, statistics instructor
Treasure Valley Math and Science Center
Boise, Idaho

Norris Williams, Ph. D.
Retired, Curartor Emrttitus
FLMNH
Gainesville, Florida

Rebecca Windell, M.S.
Graduate Research Assistant
University of Washington
Okanogan, Washington

Heidi Wipf, Ph. D. Candidate
Graduate Student Researcher
University of California, Berkeley
Albany, California

Shaye Wolf, Ph. D.
Climate Science Director
Center for Biological Diversity
Oakland, California

Mark Woods, Ph. D.
Professor of Philosophy
University of San Diego
San Diego, California

George M. Woodwell, Ph. D.
Founder, President, Director Emeritus
The Woods Hole Research Center
Woods Hole,, Massachusetts

Jeff Writer, Ph. D.
Instructor
University of Colorado
Boulder, Colorado

Tiffany Yap, Ph. D.
Scientist, Wildlife Corridor Advocate
Center for Biological Diversity
Oakland, California

SOUTHEAST ALASKA

By the Numbers 2019

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CHANGES **2017 TO 2018**

Regional **population** decreased by **80 people** to **72,876**

Labor force increased by **2 jobs** to **45,642** jobs

Total Government jobs decreased by **108 jobs** to **13,148**

Cruise **Passengers** increased by **7% to 1.2 million**

Pounds of Seafood Landed in the region decreased by **118 million pounds,** a decrease of **39%**

Health Care Jobs in the region increased by **121**, a gain of **3%**

SOUTHEAST ALASKA'S **ECONOMY**

The Southeast Alaska summer of 2019 was filled with record-high temperatures and a historic number of visitors spending money across the region's communities. While it was the picture of prosperity, the region's complex economic framework is thriving in some segments, while struggling in others.

Southeast Alaska's shrinking State sector is down by more than 800 jobs over 7 years. Long the top provider of wages in the region, state government is on track to be a distant third in coming years – after municipal government and tourism – and a bountiful fishing season would make the state the fourth largest provider of wages. Alaska's fiscal health has been managed to the detriment of Southeast Alaskans, as short-term gains took priority over the long-term economic health of the State sector, and State savings were depleted without full implementation of a sustainable fiscal solution. As a result the region has been embroiled in economic uncertainty that is a problematic companion to a thriving private sector.

The regional health care industry had been optimistic about the trajectory of the economic environment, adding nearly 500 jobs and $50 million in wages over the last four years to support the growing health care needs of an aging population. However, steep state cuts to Medicaid funding, compounded by the potential loss of matching federal dollars, have reversed the growing business confidence of that sector. The region's mining sector has been growing, while the ship building and construction sectors have contracted.

Fishing remains mercurial. Southeast Alaska lost nearly 700 seafood jobs in the past four years, with wages down by $22 million. By volume, the catch for 2018 was the lowest in decades, but strong seafood prices have offset losses. The so-called trade war with China is having deleterious impacts on several Southeast industries, including seafood, timber, and mining.

Through all of this, the visitor industry has provided a critical counter-balance to a capricious economy. In just seven years, the tourism sector added more than 2,000 annualized jobs to Southeast communities, increasing wages by $85 million. During the summer of 2020, 1.44 million visitors are projected to spend nearly $800 million during their Southeast Alaska holidays.

The collective result was a flat economy in 2018. Southeast Alaska decreased in population by 80 people, added two jobs, and overall wages grew incrementally. The region persevered through several rough years, but Southeast Alaskans are resilient and remain optimistic about the future. More than a quarter of regional businesses plan to add jobs in the coming year, and 68% of business leaders expect the coming year to be positive and/or better than last year.

SOUTHEAST **2020 STRATEGIC PLAN** SUMMARY

The Southeast Alaska 2020 Economic Plan, is a five-year strategic plan for the region. The membership worked together to develop an overall vision statement, 46 objectives, and 7 priority objectives, along with regional and industry specific SWOT analyses. More than 400 people representing small businesses, tribes, Native organizations, municipalities, and nonprofits were involved in various elements of the planning process. In 2018 this work received a national NADO Innovation Award. The Plan's objectives are listed below.

Transportation

★ **Priority** Minimize Impacts of Budget Cuts to AMHS and Develop a Sustainable Operational Model.
Road Development.
Move Freight to and from Markets More Efficiently.
Ensure the Stability of Regional Transportation Services Outside of AMHS.

Energy

★ **Priority** Promote Priorities of the Regional Energy Plan, Including Infrastructure and Diesel Displacement.
Support Community Efforts to Create Sustainable Power Systems that Provide Affordable/Renewable Energy.
Complete Regional Hydrosite Evaluation for Southeast Alaska.

Maritime

Maritime Industrial Support

★ **Priority** Maritime Industrial Support Sector Talent Pipeline: Maritime Workforce Development Plan.
Continue to Grow the Regional Maritime Sector.
Increase Access to Capital for the Regional Maritime Industrial Support Sector.
Support Capital Investments in Expanded Marine Industry Support Infrastructure.
Harbor Improvements.
Examine Arctic Exploration Opportunities That the Region as a Whole Can Provide.

Seafood Industry

★ **Priority** Mariculture Development.
★ **Priority** Full Utilization and Ocean Product Development.
Increase Energy Efficiency and Reduce Energy Costs.
Regional Seafood Processing.
Seafood Markets.
Sea Otter Utilization and Sustainable Shellfish.
Maintain Stable Regulatory Regime.
Seafood Workforce Development.

Visitor Industry

★ **Priority** Market Southeast Alaska to Attract More Visitors.
Improve Access to Public Lands.
Increase Flexibility in Terms of Permit Use.
Increase Yacht and Small Cruise Ship Visitations.
Improve Communications Infrastructure.
Advocate for Funding to Maintain Existing Recreational Infrastructure.
Grow Cultural and Arts Tourism.

Timber Industry

★ **Priority** Provide an Adequate, Economic and Dependable Supply of Timber from the Tongass National Forest to Regional Timber Operators.
Stabilize the Regional Timber Industry.
Work with USFS to Direct Federal Contracts Toward Locally-Owned Businesses.
Support Small-Scale Manufacturing of Wood Products in Southeast Alaska.
Continue Old-Growth Harvests Until Young-Growth Supply is Adequate.
Community-Based Workforce Development.
Update Young Growth Inventory.

Other Objectives

Healthcare: Meet Regional Workforce Development Needs.
Research: Attract Science and Research Jobs to Southeast Alaska.
Housing: Support Housing Development.
Food Security: Increase Production, Accessibility, and Demand of Local Foods.
Communications: Improved Access to Telemedicine in Southeast Alaska.
Marketing: Market Southeast Alaska as a Region.
Solid Waste: Regional Solid Waste Disposal.
Education: Partner with University & K-12 to Meet Workforce Needs
Arts: Increase Recognition of Southeast Alaska's Thriving Arts Economy.
Mining: Minerals & Mining Workforce Development.
Cultural Wellness: Support Activities and Infrastructure that Promote Cultural Wellness.

A Message from **Southeast Conference**

Executive Director
Robert Venables

We truly are living in "interesting times." In many economic sectors, the region is holding its own or doing well, while others struggle. The pervasive uncertainty that envelopes the region and state is cited as a top reason industry hesitates to invest, expand and grow. A stable fiscal policy is essential.

Southeast Alaska is blessed with the natural resources that can provide the basis for a strong economy. Our fisheries, mariculture, mining, timber and energy "endowment" is second to none. We need to focus on creating an environment that attracts and nurtures investment in those opportunities.

Also critical is the availability of skilled labor. Southeast Conference continues to be involved in workforce development and is a strong supporter of our University as a primary institution for preparing the next generation of workers.

Infrastructure and transportation must be present to support new and growing businesses. Southeast needs adequate ports, harbors, airports, roads, and most certainly a viable ferry system. Changes to AMHS are here, but we have a plan – and more importantly, a process guided by statewide stakeholders with a passion to see it succeed in its mission.

Our award-winning Economic Plan is our guide. This year we use it to measure how we've done the last 5 years as we update it toward our goal of strong economies, healthy communities and a quality environment in Southeast.

Robert Venables, Meilani Schijvens, and Alec Mesdag show off the National Association of Development Organizations 2018 Innovation Award, which Southeast Conference won for the Southeast Alaska 2020 Economic Plan. Photo by Heather Holt.

Incoming President
Alec Mesdag

Alec Mesdag is the Director of Energy Services for Alaska Electric Light and Power in Juneau. Together with his wife, they own and operate Salty Lady Seafood Company, a mariculture farm in Bridget Cove.

I lived in Portland for about five years. Among many strange things about living there, "Keep Portland Weird" stickers are all over the place. When I moved back to Juneau and attended my first Annual Meeting, it struck me that, in Southeast, we don't need to remind each other. I think that's the greatest advantage Southeast Conference has as an economic development organization. The membership and region have great diversity of thought, culture, and experience, and we welcome one another. That mixture drives innovation, and innovation drives growth.

One of the less-heralded bonds of our region is the need to constantly battle with visitors and in-laws from Portland about what it takes to stay warm when wet. That fundamental requirement for successfully going outside in Southeast Alaska helps underpin an ability to distinguish between reality and dogma, and that works as an analogy for what impressed me and encouraged me to become more involved in Southeast Conference. The organization's structure and economic plan acknowledge the need for continuous adaptation by government and the private sector, so the two complement each other's work without creating obstacles and distortions. That is why membership engagement in the Southeast Alaska Economic Plan has more potential to shape the trajectory of our region's economy than any other factor within our control.

The mission of Southeast Conference is to **undertake and support activities that promote strong economies, healthy communities and a quality environment in Southeast Alaska**. As the state and federally-designated regional economic development organization, Southeast Conference serves as the collective voice for advancing the region's economy. We have 200 member organizations representing 1,200 people from 32 regional communities. We started 60 years ago with a group of people supporting the establishment of a regional transportation system, leading to the formation of the Alaska Marine Highway System. Our members stayed together through more than a half-century to focus on concerns unique to the region.

Image Credits: Front cover photo of Juneau Waterfront by Zachary Hanna. Back cover photo by Bethany Goodrich, Sustainable Southeast Partnership. Icons/map by Avery Veliz.

Four Years of Change: 2014 to 2018

Table tracks key Southeast indicators over the past 4 years, along with associated changes.

Demographics	2014	2018	% Change 2014-2018	Change 2014-2018
Population [1]	74,432	72,872	-2%	-1,556
Ages 65 and older [2]	9,243	11,089	20%	1,846
Under Age Five [2]	4,622	4,146	-10%	-476
Twenty somethings [2]	9,398	8,447	-10%	-951
K-12 School District Enrollment [3]	11,804	11,334	-4%	-470
General Economic Conditions				
Total Labor Force (jobs, includes self-employed & USCG)[1,5,6]	45,694	45,642	0%	-52
Total Job Earnings[1, 5, 6]	$2.17 billion	$2.28 billion	5%	+$109 million
Total Private Sector Payroll [1, 6]	$1.41 billion	$1.51 billion	7%	+$97 million
Average Annual Wage [1]	$47,593	$50,023	5%	$2,430
Annual Unemployment Rate [1]	7.1%	6.0%	-1.1%	-1.1%
Top Economic Sectors	**2014**	**2018**	**% Change**	**Change**
Government	Public Sector: 35% of all employment earnings			
Total Government Employment [1, 5]	13,602	13,148	-3%	-454
Federal Employment [1, 5] (8% of all employment earnings)	2,110	2,111	0%	1
State Employment [1] (14% of all job earnings)	5,504	4,771	-13%	-733
City and Tribal Employment [1] (14% of all job earnings)	5,988	6,266	5%	278
Total Government Payroll (includes USCG) [1, 5]	$765.8 million	$776.9 million	1%	+$11 million
Total State of Alaska Payroll	$311.3 million	$283.3 million	-9%	-$28 million
Visitor Industry	Key Industry: 11% of all employment earnings			
Total Visitor Industry Employment [1, 6]	6,923	8,004	16%	1,081
Total Visitor Industry Wages/Earnings [1, 6]	$188.5 million	$249.3 million	32%	+$60.8 million
Total Southeast Alaska Passenger Arrivals	1,359,897	1,618,311	19%	258,414
Cruise Passengers [10]	967,500	1,169,000	21%	201,500
Total Air Passenger Arrivals from Outside SE [11]	372,197	435,476	17%	63,279
Total AMHS Passengers from Outside SE [12]	20,200	13,835	-32%	-6,365
Commercial Fishing & Seafood Industry	Key Industry: 10% of all employment earnings			
Total Seafood Employment (includes fishermen) [1, 6]	4,372	3,711	-15%	-661
Total Seafood Employment Earnings [1, 6]	$259.0 million	$237.4 million	-8%	-$21.6 million
Pounds of Seafood Processed[7]	232.9 million	132.7 million	-42%	-97.8 million
Pounds Landed (commercial seafood whole pounds by SE residents) [8]	300.0 million	185.2 million	-38%	-114.8 million
Estimated Gross Earnings (ex-vessel value of pounds landed) [8]	$277.1 million	$246.9 million	-11%	$30.2 million
Shared Fish Taxes[13]	$5.8 million	$4.5 million	-22%	-$1.2 million
Health Care Industry (public & private health)	Key Industry: 11% of all employment earnings			
Health Care Employment [1, 6]	3,523	3,990	13%	467
Health Care Wages [1, 6]	$194.8 million	$243.3 million	25%	+$48.5 million
Maritime Economy (Includes employment from all industries)	Top Sector: 27% of Private Sector employment earnings			
Private Maritime plus USCG Employment [1,5,6]	6,768	6,273	-7%	-495
Private Maritime plus USCG Wages [1,5,6]	$395.5 million	$396.8 million	0%	+$1.3 million
Other Selected Statistics	**2014**	**2018**	**% Change**	**Change**
Construction Employment [1, 6] (6% all employment earnings)	2,168	1,909	-12%	-259
Mining Employment [1] (4% of all employment earnings)	783	889	14%	106
Price of Gold [7]	$1,266	$1,268	0%	$2
Total Southeast AMHS Ridership[12]	242,648	179,312	-26%	-63,336
Cost of Living: Consumer Price Index[1]	215.8	225.5	5%	9.7
Housing Starts: Housing Permitted /Completed [4,1]	321	188	-41%	-133
Avg. Daily Volume ANS Oil Production (mbbls/day)[14]	512,810	508,601	-1%	-4,209
Annual Avg. Domestic Crude WTI Oil Prices (in $/Barrel)[14]	$97.88	$71.71	-27%	-$26

Sources: [1]Alaska Department of Labor (ADOL); [2]ADOL Southeast Alaska Population by Age, 2014 to 2018; [3]Alaska Department of Education and Early Development; [4]Based on the quarterly Alaska Housing Unit Survey, a survey of local governments and housing agencies; [5] US Coast Guard; [6] 2017 US Census Nonemployer (self-employment) Statistics; [7]Kitco Metals Inc.; [8]ADF&G Southeast Alaska Commercial Seafood Industry Harvest and Ex-Vessel Value Information, 2014-2018; [10]Cruise Line Agencies of Alaska; [11]US Bureau of Transportation Statistics (RITA); [12]Alaska Marine Highway System data; [13]Shared Taxes and Fees Annual Report FY17, ADOR; [14]Alaska Department of Revenue *Crude Oil and Natural Gas Prices*.

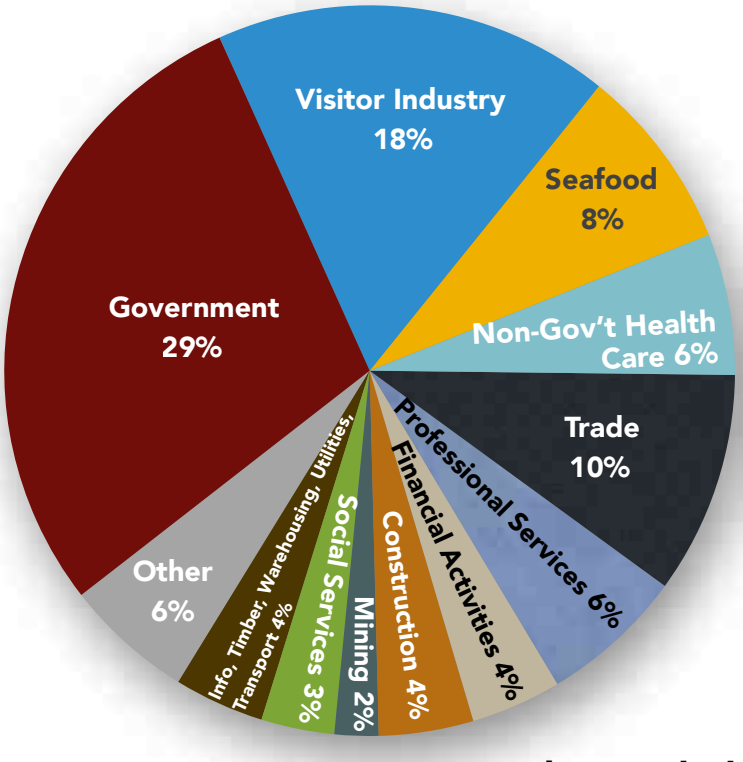
The Whole **Southeast Alaska Economy** 2018

In 2018, Southeast Alaska gained 380 year-round equivalent jobs and $17 million in workforce earnings over 2017. Approximately a quarter (26.1%) of regional workers are non-residents.

Annual Average Jobs

45,642 Jobs

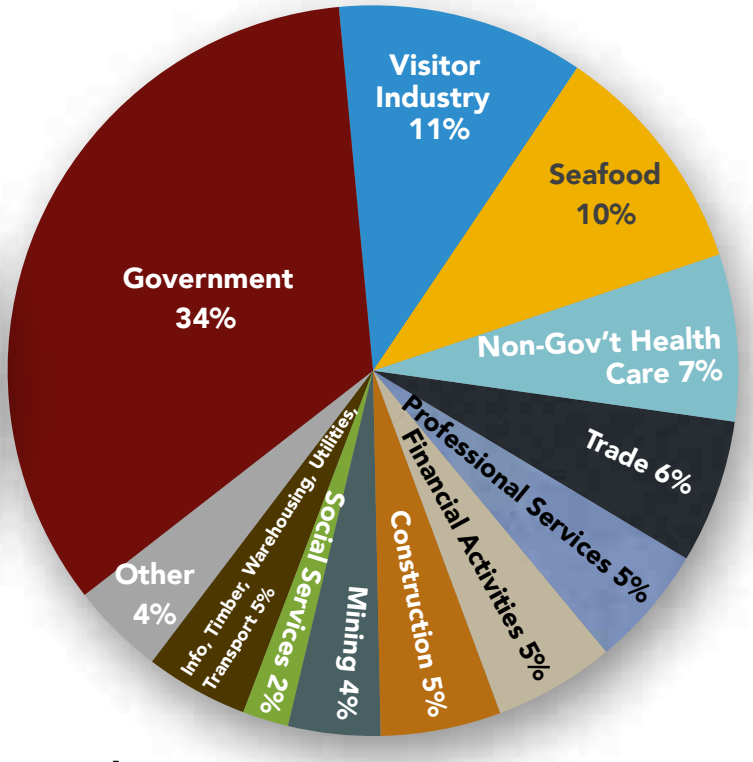
Up 2 Jobs in 2018 +0%



Employment Earnings

$2.3 Billion Workforce Earnings

Up $86 Million +4%



2018 Southeast Alaska Employment Earnings

	Employment Related Earnings			Employment Numbers		
	Wages (2018)	Self-Employment Earnings (2017)	Total Earnings	Annual Average Employment (2018)	Self-Employed (2017)	Total Employment
Government (includes Coast Guard)	$721,459,750	$55,467,580 CG*	**$776,927,330**	12,486	662 CG*	**13,148**
Visitor Industry	$216,101,975	$33,241,000	**$249,342,975**	7,037	967	**8,004**
Seafood Industry	$61,983,458	$175,459,000	**$237,442,458**	1,458	2,253	**3,711**
Trade: Retail and Wholesale	$120,405,013	$24,666,000	**$145,071,013**	3,903	587	**4,490**
Health Care Industry (private only)	$154,278,150	$14,330,000	**$168,608,150**	2,615	237	**2,852**
Construction Industry	$88,673,702	$32,972,000	**$121,645,702**	1,331	578	**1,909**
Financial Activities	$52,935,761	$69,216,000	**$122,151,761**	1073	757	**1,830**
Professional and Business Services	$78,756,495	$44,242,000	**$122,998,495**	1,606	1,304	**2,910**
Mining Industry	$92,753,768	$274,000	**$93,027,768**	879	10	**889**
Social Services	$42,218,089	$4,224,000	**$46,442,089**	1,289	187	**1,476**
Information (publishing, broadcasting, telecomm.)	$22,074,083	$1,474,000	**$23,548,083**	483	58	**541**
Timber Industry	$16,739,683	$2,025,000	**$18,764,683**	280	57	**337**
Warehousing, Utilities, & Non-Visitor Transport	$46,340,395	$15,414,000	**$61,754,395**	777	166	**943**
Other	$66,819,751	$27,657,000	**$94,476,751**	1,677	925	**2,602**
Total	$1,781,540,073	$500,661,580	$2,282,201,653	36,894	8,748	45,642

Sources: Alaska Department of Labor 2018 Employment & Wage data; 2017 (latest available) US Census Nonemployer (self-employment) Statistics; Active Duty Military Population by 2018, ADOL.*These cells in Government refer to 2018 active duty Coast Guard personnel employment and wages, and not self-employment data.

Notes: Seafood Industry includes animal aquaculture, fishing & seafood product preparation, and Southeast Alaska resident commercial fishermen (nonresident fishermen & crew who did not report income are excluded). **Visitor Industry** includes leisure & hospitality, and visitor transportation (air, water, scenic). **Timber** includes forestry and logging support activities for forestry, and wood product manufacturing.

Southeast Tourism Statistics 2020

Estimated Regional Visitor Industry Projections for 2020

43
Cruise Ships in Southeast

606
Cruise Ship Voyages

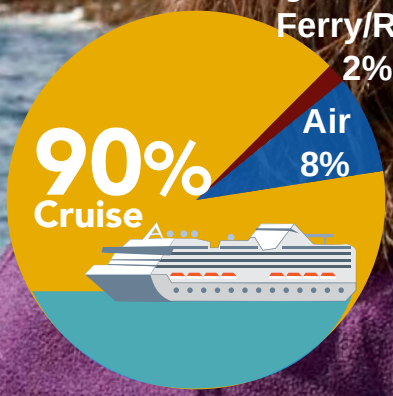
1.44
Million Cruise Passengers

$793
Million in Tourist Spending

2020

65%
Increase in cruise passengers from 2010

Tourist Arrivals in Southeast by Mode

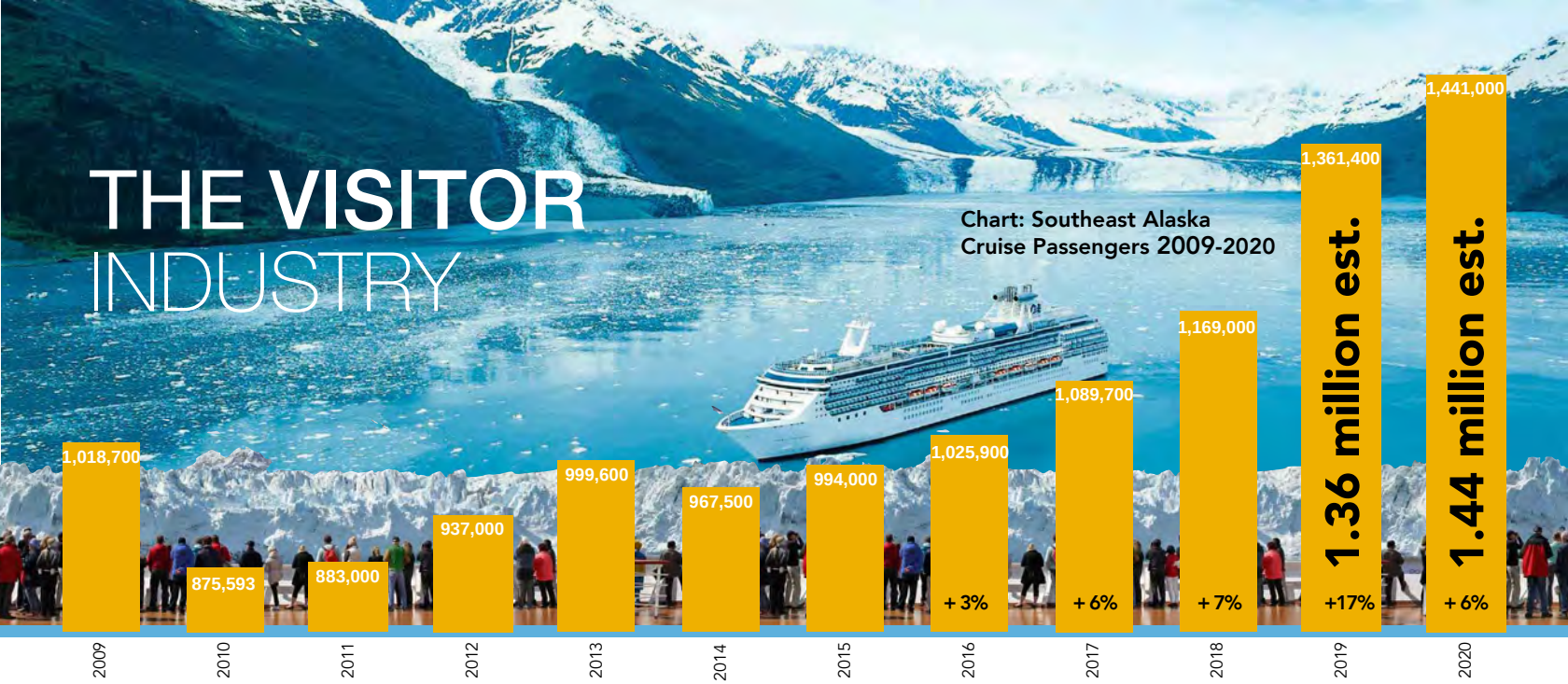


Southeast Alaska Cruise Passengers Arrivals by Port

Port	2018 actuals	2019 projected	2020 projected	% of all passengers	Change 2018 to 2020
Juneau	1,151,094	1,325,792	1,421,929	99%	24%
Ketchikan	1,053,764	1,212,033	1,275,636	89%	21%
Skagway	957,847	1,044,107	1,070,610	74%	12%
Gustavus (Glacier Bay)	569,807	636,811	584,528	41%	3%
Hoonah (Icy Strait Point)	189,000	272,327	404,033	28%	114%
Sitka	158,362	224,379	210,399	15%	33%
Haines	57,798	67,799	78,322	5%	36%
Wrangell	11,974	17,342	17,742	1%	48%
Total Southeast	1,169,000	1,361,400	1,441,000	100%	23%

Sources: Cruise voyage and passenger number projections provided by Cruise Lines International Association Alaska. Excludes numbers for some smaller cruise ships. Spending and mode projections developed by Rain Coast Data based on CLIAA, AVSP VII, US Bureau of Transportation Statistics, and Alaska Marine Highway System data.
Photo Credit: Tourists aboard an Allen Marine vessel in Sitka, by Peter Metcalfe.

THE VISITOR INDUSTRY



Visitor Industry
8,004 Annualized Jobs

Up 265 Jobs in 2018 +3%
Wages up 8%

The visitor industry is the largest private sector industry in Southeast, both in jobs and, since 2016, in total workforce earnings (see chart on page 5). Indeed, if the industry continues to grow it is set to eclipse both the municipal and state government sectors in total wages (it is already larger than both in terms of employment) and become the region's largest sector overall. The visitor industry accounted for 18% of regional employment (8,004 annual average jobs) and a quarter of all private sector employment.

Since 2011, tourism has added more than 2,000 year-round equivalent jobs to the Southeast economy. Those working in the visitor industry earned $249 million in 2018—or 11 percent of all regional employment income. The average annualized wage in the visitor industry is $31,152, significantly lower than the average regional wage of $50,002, but it is a figure that has been steadily increasing over time.

In 2018, 1.6 million air, ferry, and cruise passengers came to Southeast Alaska from outside the region, a 19% increase over 2014. Airline passenger traffic from outside the region grew 17%, and cruise passenger traffic to the region increased by 13%. However, ferry arrivals from outside the region fell by 32% due to decreases in funding and service.

Cruise Ship Traffic

Most passengers arriving in the region come by cruise ship than any other mode. When tourists only are considered, that figure will be 90% by 2020. Cruise passenger traffic has seen massive increases in recent years. Between 2010 and 2020, the number of cruise passengers arriving in the region is projected to increase by a staggering 65%, including two-year growth of 23% expected between 2018 and 2020. Southeast Alaska will receive 5% of all global cruise ship passengers in 2019.

In 2019, 40 cruise ships are scheduled to visit the region, carrying 1.36 million passengers on 577 voyages. In 2020, ten new ships and 29 additional port calls are expected to be added, while 7 ships will be phased out of the region. Lines with new ships will include Carnival, Princess, Royal Caribbean, Norwegian, and Oceania. Lines that plan to reduce their Alaska fleet include Holland America, Crystal, and Azamara, which has no ships scheduled to visit Alaska in 2020.

Key Economic Driver

Southeast Alaska is the most visited part of the state, with two-thirds of all tourists coming to the region. One-third of all Alaska visitor spending occurs in Southeast, where visitors are expected to spend nearly $800 million in 2020.

Increased Jet Service

For the fourth year in a row, in 2018 Southeast Alaska saw a record-breaking number of airline passengers from outside the region, with 435,476 arrivals. However, in 2019 air passenger numbers declined. As of July 2019, airline passenger arrivals were down 4% over the first half of 2018.

Visitor Outlook

The visitor industry has the strongest outlook of all Southeast Alaska industries. Alaska's popularity as a visitor destination has continued to grow. In 2018, Glacier Bay was rated the best cruise designation in the world by cruisers. More Americans are traveling due to a strong national economy and international travel destinations are increasingly perceived to have security risks. Cruise passenger arrivals are expected to continue to rise as larger, higher-capacity vessels visit the region. Along with increased visitors, the number of jobs and associated income in this sector will continue to rise.

However, Southeast's strong visitor economy is tied to a strong national economy. As more signals suggest the possibility of a national recession, the region should be prepared for this sector to see a reduced number of visitors if a recession does occur.

Sources: Combination of ADOL 2018 Employment and Wage data and 2017 US Census Nonemployer (self-employment) Statistics; McDowell Group; US Bureau of Transportation Statistics (RITA); Alaska Marine Highway System; Cruise Line Agencies of Alaska; Cruise Market Watch; Cruise Critic; Juneau International Airport Passenger Statistics; Economic Impact of Alaska's Visitor Industry. Forecast 2020 U.S. Department of Commerce, US Office of Travel and Tourism Industries. OMB budgets. Cruise Lines International Association Alaska.
Note: In this analysis, the visitor industry includes leisure and hospitality businesses, along with air, water & scenic transportation companies.
Photo Credit: Cruise Lines International Association Alaska & Shutterstock 290564897.

SOUTHEAST MARITIME: **6,273 Jobs**

Private and US Coast Guard Maritime Employment & Workforce Earnings (-2 jobs 2017-2018)

Fishing & Seafood Processing
Jobs: **3,508**
Wages: **$237.4 M**
Change in jobs 2014-18: **-20%**

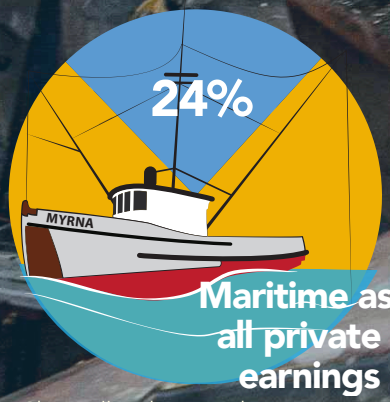
Marine Tourism
Jobs: **1,258**
Wages: **$47.2 M**
Change in jobs 2014-18: **+68%**

US Coast Guard
Jobs: **793** (Active Duty and Civilian)
Wages: **$66.4M**
Change in jobs 2014-18: **+5%**

Marine Transportation (Excluding Tourism)
Jobs: **367**
Wages: **$24.8M**
Change in jobs 2014-18: **-5%**

Ship Building, Repair, Marinas
Jobs: **326**
Wages: **$19.1 M**
Change in jobs 2014-18: **+73%**

Marine-Related Construction
Jobs: **21**
Wages: **$1.8 M**
Change in jobs 2014-18: **-75%**



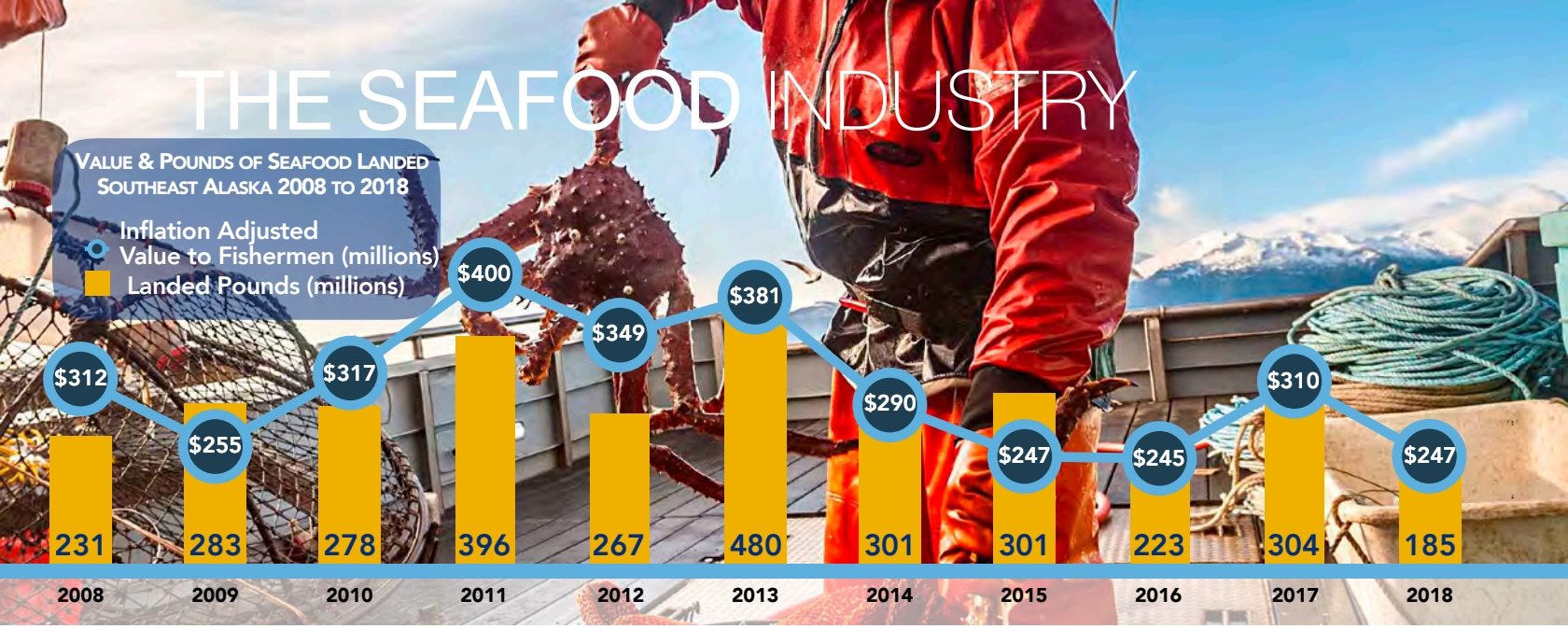
Maritime as a % of all private sector earnings in SE

Southeast Private & USCG Maritime Economy 2014-2018

Total Jobs 2018: **6,273**
Total Wages 2018: **$396.8 Million**
Change in jobs since 2014: **-495**
Change in jobs by percent: **-7%**
Change in earnings since 2014: **-$1.3 Million**
Change in earnings by percent: **-0.3%**

Photo by Chris Miller Photography.
For methodology, notes, and sources, see *www.raincoastdata.com/sites/default/files/Maritime by the Numbers.pdf*

THE SEAFOOD INDUSTRY



Southeast Seafood Industry 3,711 Jobs

Down 118 Jobs in 2018

The regional 2018 fishing season was significantly below the ten-year average, and total pounds landed was the lowest since the 1980s. Poor pink salmon and herring returns are primarily to blame. The Southeast Alaska seafood harvest in 2018 was 185 million pounds with an ex-vessel value of $247 million. An "average" year would have netted 117 million more pounds of seafood, and earned fishermen $57 million in direct earnings. Fishermen caught 100 million fewer pounds of pink salmon than would be expected in an average year, and 19 million fewer pounds of herring. However, a strong chum return helped offset some of these losses.

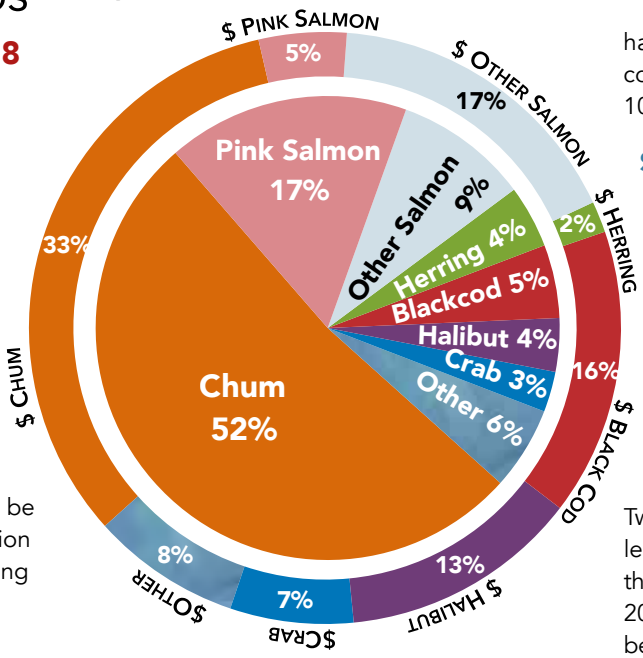
Key Economic Driver

The regional seafood industry (including commercial fishing and seafood processing) generated 3,711 annual regional jobs and $237 million in earnings in 2018, making up 8% of jobs in the region and 10% of earnings. This represents 118 fewer jobs than last year, and a loss of 650 jobs since 2015.

The majority of the statewide catch of Chinook, coho, keta (chum), shrimp, Dungeness crab, and the dive fisheries occurs in Southeast Alaska. In 2018, the five salmon species represented 78% of the regional seafood catch by volume, and just over half of total ex-vessel value ($135 million). Halibut and black cod, at 9% of the total catch, accounted for nearly one-third of total catch value in 2018.

Seafood Landed in SE Alaska by Species, 2018

Outer ring = % of harvest by DOLLAR value: $247 million
Inner pie = % of harvest by POUNDS landed: 185 million



Pink salmon were 76% below 10-year averages. Warm sea temperatures between 2013 and 2016 are being blamed for the reduction in pink salmon.

There was significant variability across fisheries in 2018. Southeast Alaska's 2018 king salmon season was the worst in 57 years of record-keeping, and 2019, with limits set by the Pacific Salmon Treaty, will be even worse. The sockeye salmon harvest was also one of the poorest on record, 47% below 10-year average harvest levels, as was Dungeness crab. In contrast, the 2018 chum salmon return was the 10th largest since statehood.

Seafood Processing

In 2018, shore-based seafood facilities in Southeast Alaska processed 133 million pounds of seafood, with a wholesale value of $439 million, a 42% decrease in seafood pounds processed over 2017. State-shared fisheries taxes for processing activity in FY18 generated $4.5 million for regional communities.

Seafood Industry Outlook

Two-thirds of regional seafood business leaders reported an unfavorable outlook for their industry. While the preseason forecast for 2019 of 44 million salmon was somewhat below typical years, only 60% of that number had been realized by the late summer 2019, mostly due to a poor Chum return. Only a quarter of the expected Chum had been captured by early September.

Uncertainty related to harvest fluctuations, a return of warming ocean temperatures (known as "the blob"), Chinese tariffs, commercial fisheries budget cuts, and global advances in salmon farming all contribute to growing concerns. Retaliatory tariffs imposed by China have already caused a one-third drop in US seafood sales, and more seafood tariffs are set to be enacted on December 15th. Meanwhile, the regional mariculture industry has been growing.

Sources: Combination of ADOL 2018 Employment and Wage data; 2017 US Census Nonemployer (self-employment) Statistics; ADF&G Seafood Production of Shorebased Plants in Southeast Alaska; ADF&G Southeast Alaska Commercial Seafood Industry Harvest and Ex-Vessel Value Information; Run Forecasts and Harvest Projections for 2019 Alaska Salmon Fisheries and Review of the 2018 Season; ADF&G March 2019; Shared Taxes and Fees Annual Report FY18, ADOR; Alaska Commercial Salmon Harvests and Ex-vessel Values, ADF&G. **Seafood Industry** includes animal aquaculture, fishing, & seafood product preparation and Southeast Alaska resident commercial fishermen (nonresident fishermen & crew who did not report income are excluded). Laine Welch Fish Factor. **Photo**: Chris Miller Photography.

THE HEALTH CARE INDUSTRY

24% wage growth in 3 years

Health Care
3,990 Jobs

Up 121 Jobs in 2018
+3.1%

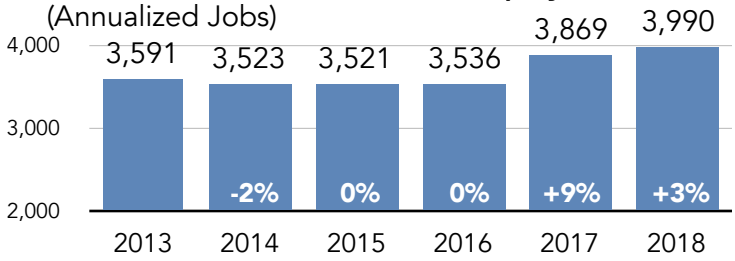
Since 2017, regional health care jobs have finally been growing after years of remaining essentially flat, and even declining.

In 2018, there were 3,990 annual average (year-round equivalent) health care jobs in Southeast Alaska, comprising 9% of the total regional workforce. Between 2016 and 2018, total health care employment increased by 12.5%, for a gain of more than 450 jobs. High worker replacement rates, partly due to the high use of traveling health care workers, means that the total number of people working in the regional health care industry is higher than the annual average job number, with more than 5,000 workers participating in the Southeast Alaska's health care industry in 2018.

The top health care employers in the region are Southeast Alaska Regional Health Consortium (SEARHC) with nearly 1,200 staff, Juneau's Bartlett Regional Hospital with approximately 650 employees, and PeaceHealth Ketchikan Medical Center with nearly 500 workers. Just over a quarter (28%) of health care jobs (1,130) are government jobs, including municipal hospital workers and State of Alaska Pioneer Homes staff.

Regional health care wages have grown significantly in recent years, increasing by $47 million, or 24%, over the past three years, from $195 million in 2015 to $243 million in 2018. Southeast Alaska's health care workers earned 11% of all regional wages last year. The total economic impact of the health care industry in Southeast Alaska in 2018 was $569 million.

Southeast Alaska Health Care Employment
(Annualized Jobs)



Despite growing health care needs in the region due to an aging populace and growing patient volumes, health care employment and wages stagnated through 2016 amid political uncertainty over national health care policy, proposed Medicare cuts, and cuts to state Medicaid. Once that uncertainly appeared to be resolved, hiring increased significantly.

Nationally competition for health care jobs is fierce. With more health care workers needed nationally to support an aging America and more Americans accessing health care, there is a shortage of medical professionals entering the workforce. Medical and nursing schools graduate a similar number of students as they did two decades ago, and baby boomers are retiring. Regional wages were found not to be competitive enough to attract and retain sufficient talent. Southeast providers had to adjust wages upward to remain competitive in attracting workers, resulting in the significant total wage increase.

Whether or not this trend continues is up in the air, as political uncertainty surrounding health care is back.The Spring 2018 Southeast Alaska Business Confidence survey showed that the health care sector was the most optimistic among all regional sectors. However, in December 2018 the governor proposed steep cuts to health care and Medicaid spending across the State of Alaska, which would also result in the loss of matching federal dollars. There are 19,815 individuals enrolled in Medicaid across the region. By Spring 2019 the annual confidence survey showed that health care sector leaders dropped to become the least optimistic in the span of just a year. (See page 17).

In 2019, Southeast Conference conducted a Southeast Alaska health care workforce survey to measure the future workforce needs of regional health care providers along with the obstacles to meeting those needs. Top management from 22 regional health care organizations completed the survey, representing 3,161 health care workers, or 80% or all health care staff. The survey was commissioned by the University of Alaska Southeast, University of Alaska Anchorage, Bartlett Regional Hospital, the Southeast Alaska Regional Health Consortium, and Alaska State Hospital and Nursing Home Association. The following page summarizes some of the survey's key findings.

Source: Southeast Alaska Health Care Workforce Analysis September 2019, Southeast Conference. **Photo credits:** Peter Metcalfe

Southeast Alaska Health Care **Workforce Analysis**

Best/Least Effective **Recruitment** Strategies

Southeast Alaska health care leaders were asked to rank the effectiveness of 16 recruitment strategies. This chart is a weighted ranking of their highest and lowest ranked tools.

The most effective recruitment tools for Southeast health care institutions include higher wages and providing flexible work arrangements.

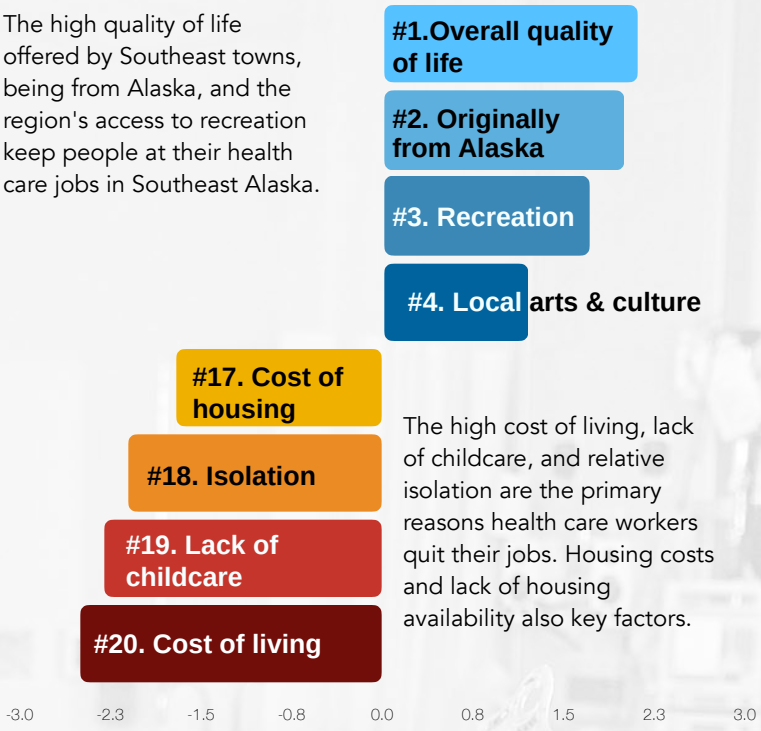
The least effective recruitment tool was use of job fairs.

Primary **Retention & Turnover** Factors

Health care leaders asked to rank the significance of 20 factors that result in long-term retention, or in staff turnover.

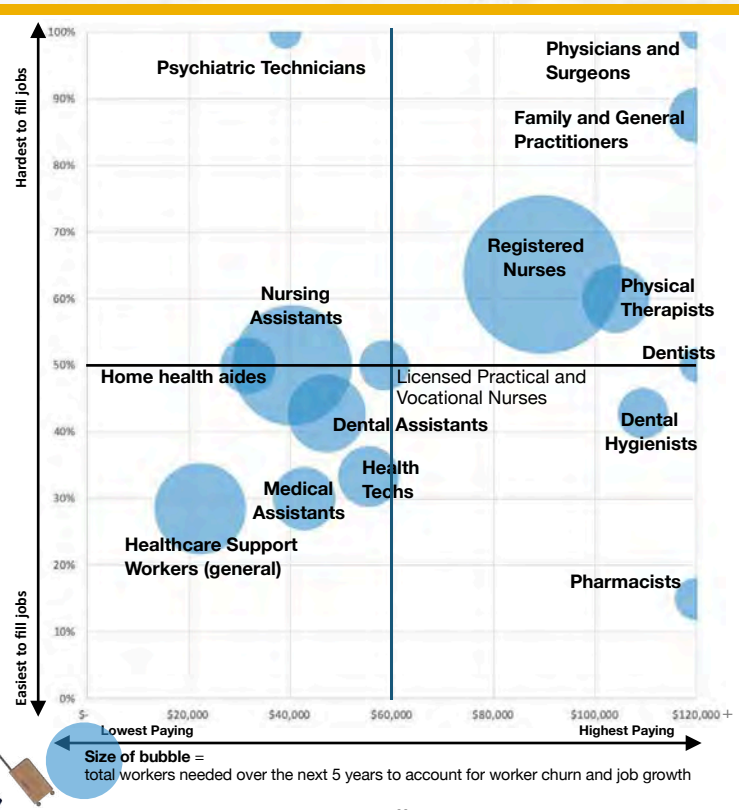
The high quality of life offered by Southeast towns, being from Alaska, and the region's access to recreation keep people at their health care jobs in Southeast Alaska.

The high cost of living, lack of childcare, and relative isolation are the primary reasons health care workers quit their jobs. Housing costs and lack of housing availability also key factors.



Workforce 5 Year Development Needs

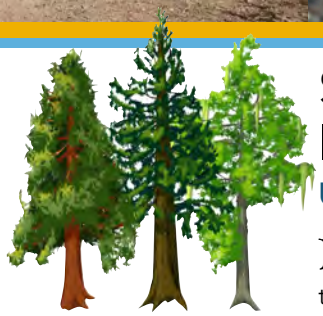
This bubble chart cross-tabulates earnings, recruitment ease, and turnover, and compiles a single picture of the region's future health care workforce needs. It provides a visual blueprint as to where the most resources should be focused when attracting workers to the region, or for "growing our own" workforce. Registered nurses have the highest workforce development need. Last year, 824 registered nurses worked in the region, although the average quarterly worker count was 628, meaning there was significant worker churn in those positions. Moreover, it is hard to fill registered nurse jobs, 82% of health care organizations in the region say it is a difficult position to fill, including 64% who say it is very difficult. While the position is not growing as fast as others — the projected growth for this position is 5% in five years — combined growth and turnover rates mean that **an additional 543 registered nurses will be needed in the region over the next five years**, assuming nothing is done to stem the high rate of turnover. Nursing assistants will also be in high demand, with 312 new positions in need of filling by 2023. While physicians, surgeons, and psychiatric technicians are the hardest positions to fill, the total number of positions forecast to be in need of filling over the next five years is comparatively smaller at 49 combined positions.



Traveling **Health Care Workers**

Use of traveling health care workers is another important tool that the regional health care industry can use to staff their organizations. Last year, nearly 350 traveling health care workers came to Southeast Alaska. Travelers are both positive and problematic for the Southeast Alaska health care industry. While each of those traveling health care workers represents additional capacity, they also represent additional costs. According to survey analysis, it costs 30% to 250% more to engage a traveling health care worker than it would be to hire a permanent employee, depending on the organization.

Southeast **Timber Industry** 337 Jobs



Down 17 Jobs in 2018 -5%

Regional timber jobs declined by 5% in 2018. The workforce is down to 337 jobs in 2018, with total earnings of $18.8 million. Most of the region's timber jobs are concentrated on Prince of Wales Island, which is home to Viking Lumber, the last remaining mid-sized sawmill in Southeast Alaska. Southeast timber jobs peaked at 3,543 annual average jobs in the 1990s.

In 2001, the Roadless Rule dramatically curtailed logging, roadbuilding, and mineral leasing in all national forests. The Tongass was temporarily exempted from the rule in 2003, but in 2011 that exception was overturned, further limiting access to regional timber stands. Maintaining a sufficient timber supply has been challenging. Even in parts of the Tongass where the rule does not apply, timber sales face regulatory and economic hurdles, and constant legal challenges.

In 2019, the USFS indicated that exempting the Tongass from the Roadless Rule could be the preferred alternative in the draft environmental impact statement to be issued in the fall. The final impact statement and record of decision will not be completed until late 2020 and will be subject to years of litigation. Removal of Roadless Rule restrictions could make more suitable timber land available for harvesting and increase forest-related employment. However, the Forest Service would still have to amend its 2016 management plan before new timber sales could be readied.

Currently, the regional timber supply remains low. A land exchange between the Mental Health Trust and the US Forest Service opened up areas for timber harvest in 2019, although ongoing process arguments have delayed phase 2 of that project, which could have a negative effect on the short-term regional timber supply.

The trade war is also impacting the timber sector. Spruce has been the subject of higher Chinese import tariffs, stalling sales in northern Southeast, where the forests are primarily spruce. The longer-term impact of the trade disputes remains unknown at this time.

Sources: ADOL 2018 Employment and Wage data; Kitco Metals Inc; Coeur Mining Inc. 2018 Annual Report; Hecla Mining Company 2018 Annual Report.
Photo credits: Bryce Dahlstrom, Viking Lumber and Constantine Metal Resources.

Southeast **Mining Industry** 889 Jobs

Up 3 Jobs in 2018

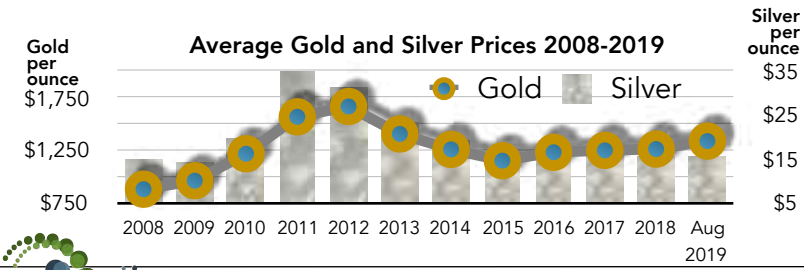
Mining industry employment in the region was flat in 2018, and is on track for 2019 to maintain a similar number of workers. In 2018, there were 889 annual average mining jobs in Southeast Alaska, with a payroll of $93 million. Two large mines operating in the region account for most (93%) of mining employment. In August 2019, Hecla Greens Creek employed 436 full-time permanent employees (+5 from 2018), while Coeur Alaska Kensington had a staff of 386 (-3 from 2018). Average annual wages of $104,650 in 2018 were up 2% from 2017. Mining jobs remain the highest-paying in the region, paying more than double the average regional wage of $50,002.

Hecla Greens Creek is one of the largest silver mines in the world, while the Coeur-owned Kensington is exclusively a gold mine. At Hecla Greens Creek production was mixed in 2018: silver production was down 5% to 8 million ounces, while zinc was up 5%, and gold production was up 1%. Production at Kensington was down 1%, with 113,778 ounces of gold produced in 2018. Zinc prices were up in 2018, and gold continues to rise incrementally.

Mineral exploration continues at the Palmer Zinc-Copper-Gold-Silver Project in Haines. Constantine received permits to construct an underground ramp (tunnel) for expanded exploration. The company recently released a positive Preliminary Economic Assessment, projecting an 11-year mine life with the current resources.

In September, the governor asked that Bokan Mountain, a rare earth element exploration project on Prince of Wales Island, be federally designated as a high priority infrastructure project.

The mining sector is expected to grow incrementally in 2019 and 2020, as it mitigates the impacts of new tariffs.



Construction Industry

1,909 Jobs

Down 23 Jobs in 2018 -1%

For the fifth year in a row construction employment is down, bringing employment to its lowest level since 1992. Jobs fell by 23 last year to 1,909, a combined loss of 360 jobs, or 16% decline, over five years and a $28 million corresponding drop in wages. Construction workers in the region earned $122 million in 2018 — or 5% of all Southeast Alaska employment earnings.

One positive indicator for the sector was that housing construction was up in 2018, as 13 more units were permitted or completed than in the year prior. A total of 188 new homes were permitted in 2018. However, home construction remains significantly down from previous years.

Construction outlook

Visitor industry infrastructure needs have improved the outlook for construction in the region.

- Hoonah's Icy Strait Point is constructing a 500-foot floating dock in partnership with Norwegian Cruise Lines.
- Norwegian Cruise Lines also is exploring a partnership to build a private dock north of Ketchikan at Ward Cove.
- In Juneau, Norwegian recently bid $20 million to purchase 2.9 acres of waterfront land (known as the Subport) and the area is expected to be developed.
- In Ketchikan, the city is considering a $150 million reconfiguration of its existing cruise dock to accommodate cruise vessels exceeding 1,000 feet in length.
- In Juneau, construction is underway on the the public-private waterfront Archipelago project.
- The Central Council of the Tlingit and Haida Indian Tribes of Alaska is building a heritage park in Thane.

Early employment data indicate construction-related employment is finally growing again, and is projected to grow 3% in 2019.

Education

3,096 Jobs

Up 14 Jobs in 2018 +0%

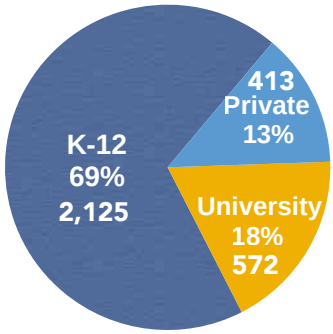
Education is a significant source of jobs in Southeast Alaska. With just over 3,000 average annual workers, the region's educators make up 7% of all regional jobs, and 6% of all regional wages. Teaching jobs provide a counterbalance to summer-centric industries like tourism, fishing, and construction jobs. Education jobs peak at 3,546 in the winter, and decline to just 1,264 positions in July. The average educator's wage in the region was $44,388 last year. Combined, educators earned $137.4 million in 2018.

Education jobs are primarily in the public sector, and 20% of all government jobs are in education. K-12 education is conducted by municipal governments, and comprise 69% of all education positions in the region, with 2,125 average annual workers in 2018, a number that has remained stable in recent years.

The university employed 558 workers in 2018, a decline of 15% compared to 2014, consistent with budget cuts that reduced funding to the University of Southeast Alaska by 13% over this period.

Private education jobs account for 13% of all education employment.

Distribution of 3,096 SE Education Jobs



School Enrollment

UAS enrollment was down by 4% from 2017 to 2,561 students in 2018. In 2018, the number of K-12 students dropped by 146 kids, to 11,334. Regionally, K-12 enrollment decreased for the 21st time in 23 years. Since 1997 annual enrollment shrank by more than 3,500 students, a 24% decline across Southeast Alaska.

Sources: Combination of Alaska Department of Labor 2018 Employment and Wage data and 2017 US Census Nonemployer (self-employment) Statistics; State of Alaska. Alaska Department of Education and Early Development; UA in Review. **Photography credit:** Rain Coast Data and UAS

GOVERNMENT

Government Jobs 2018

Local 5,266 Jobs **-84**
State 4,771 Jobs **-49**
Federal 2,111 Jobs **+1**
Tribal 999 Jobs **+24**

Government
13,148 Jobs

Down 108 Jobs in 2018 -1%

Government wages made up 34% of all regional employment earnings ($777 million) and 29% of the region's jobs (13,147) in 2018.

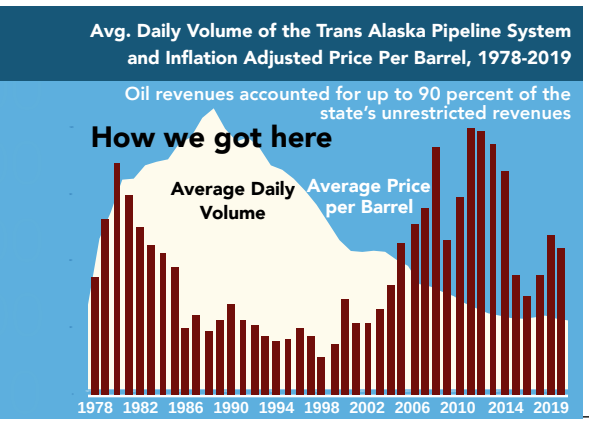
State Government Losses

State government employment and spending have continued to decline, significantly impacting the regional economy. In Southeast Alaska, 12% of all direct wages come from the state (down from 15% in 2011). State jobs have declined for seven years in a row. Historically, oil paid for up to 90% of the state budget; today, oil covers about 30 percent. Total tourism wages are on track to surpass total state wages in 2019.

State Budget Challenge

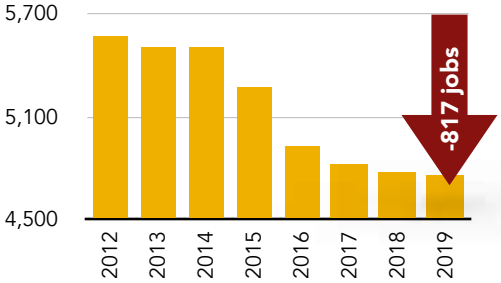
Alaska is now only America's sixth-largest oil-producing state. Declining oil production and prices devastated the State of Alaska budget. The state has operated in deficit mode for the past six years, using more than $16 billion in savings to cover budget gaps.

In February 2019, the governor proposed a plan to reign in spending by making $1.6 billion in cost reductions to the operating budget, with the bulk of the savings realized through cuts to ferries, health care, the University of Alaska, K-12 education, seniors, and creating a cost shift from the state to municipalities. Absent from the plan to balance the budget were reduced tax credits to oil companies ($1.2 billion in FY19); reduced Permanent Fund Dividend payments (a full PFD payment and repayment of previously capped dividends would cost $4.3 billion); or consideration of taxes. (See page 18 for budget survey results). The ensuing disagreement over how best to balance the budget, along with the controversial use of line item vetoes, has created an atmosphere of deep political and economic uncertainty in the region.



Southeast State Jobs

State jobs in the region are down for the 7th year in a row, for a total of 817 jobs lost since 2012, ***a decline of 15%***



Federal Government

Federal government employment losses are compounding state job cuts, but appear to have stabilized. Since 2005, federal employment in the region has fallen by 600 jobs (28%) worth $50 million in annual wages.

Local Government

Local entities across the region are having to provide new programs and services the state has cut, resulting in financial complications and resulting in the loss of 84 municipal jobs across the region. Despite these challenges, local government jobs are poised to grow slightly in 2019. Tribal government, which includes 18 entities in the region, added 24 jobs in 2018.

Government Outlook

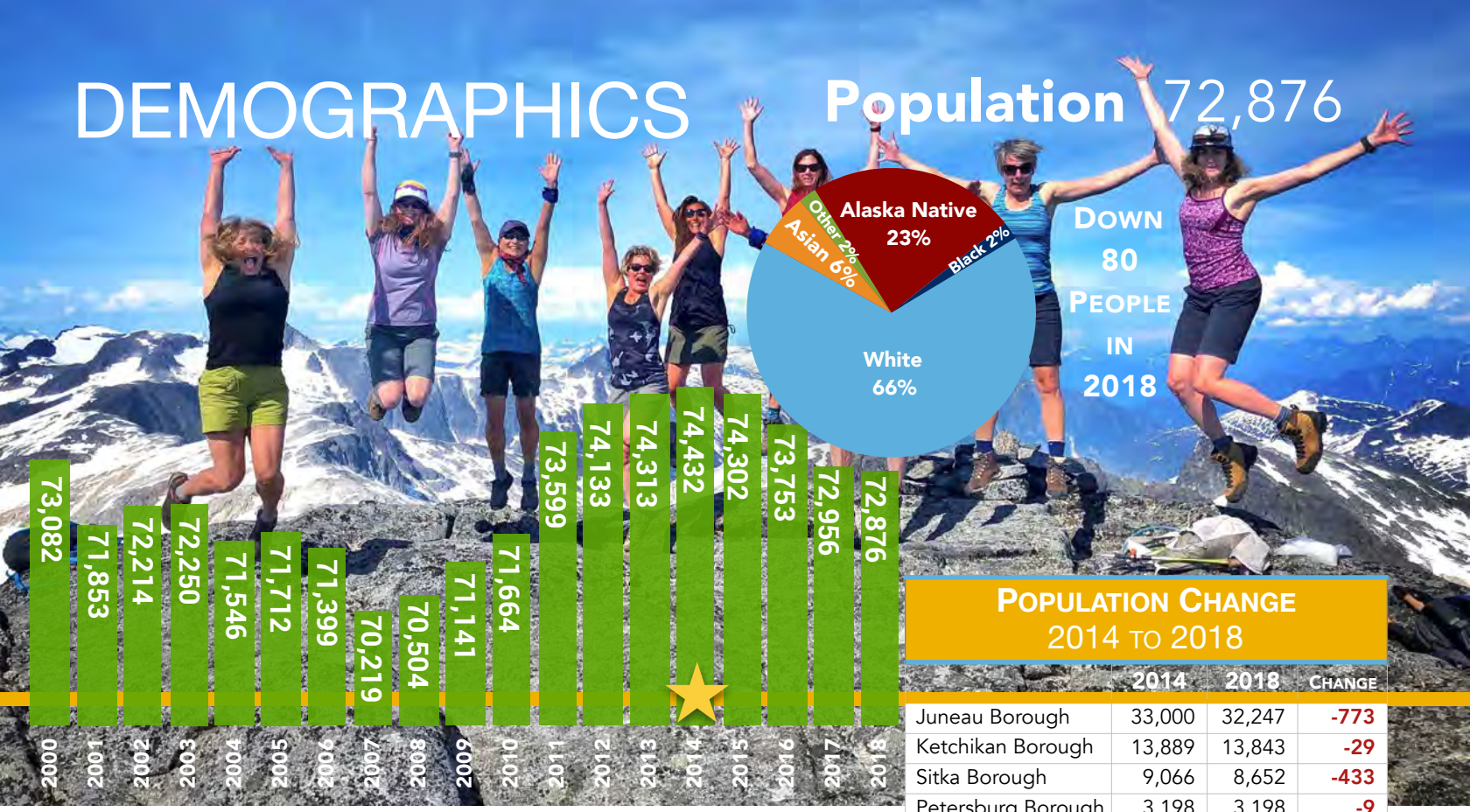
Early job reports from 2019 are somewhat positive. In the first half of 2019, only 14 additional state jobs were lost, local government jobs have grown by 2%, and federal jobs are up by 1% as well.

While legislation restructuring the $66 billion Alaska Permanent Fund passed in 2018, allowing lawmakers to use a portion of fund earnings to pay for state services and stabilize the state budget, these funds remain in limbo as the budget fight continues. The permanent fund is now more important to the budget than the oil industry, and all other taxes combined. But until a sustainable budget pathway is agreed upon and implemented, the region's economic outlook will remain uncertain.

Sources: ADOL 2018 Employment and Wage data; Alaska Department of Revenue. **Photo Credit:** Juneau Empire.

DEMOGRAPHICS

Population 72,876



2018 marked the 4th straight year of regional population decline in Southeast Alaska, but the net loss of 80 people was just a fraction of those seen in previous years. Half of the communities in the regions experienced gains in 2019, including the boroughs of Ketchikan, Petersburg, Haines, and Wrangell. In general, population losses last year were relatively small. While some communities on Prince of Wales Island, like Klawock and Coffman Cove, experienced dramatic population changes, the island population as a whole declined by 2%.

The leveling out of losses comes as relief to the region. Between 2014 and 2018, Southeast Alaska's population decreased by 1,642. The losses were region-wide, with six of eight boroughs reporting population declines. The boroughs of Skagway and Wrangell grew by 11% and less than one percent, respectively, during that period.

Juneau is the Loss Leader

Population losses were most significant in Juneau. Dramatic cuts in state employment contributed to a reduction of nearly 900 residents in the capital city over the past three years. Juneau's losses also abated in 2018, with a decline of just 55 people.

Migration

More people moved away from Southeast than moved here in 2018, but natural increases helped reduce the impact of outmigration. In 2018, there were 255 more births than deaths, while 335 more people moved out of the region than moved in.

Aging Continues

Since 2010, the most pronounced demographic shift has been aging of the population. During that period, the 60-plus population grew by 5,000 people, a 42% increase over 2010 due to aging in place. Nearly a quarter of people in the region are now age 60 or older. In Haines, Wrangell, and the Hoonah-Angoon census area, where the averages ages are 48.6, 48, and 46.8, respectively, it is nearly one-third. The average age of Southeast as a whole is 39.9. Juneau is comparatively the youngest community in the region.

Population Outlook

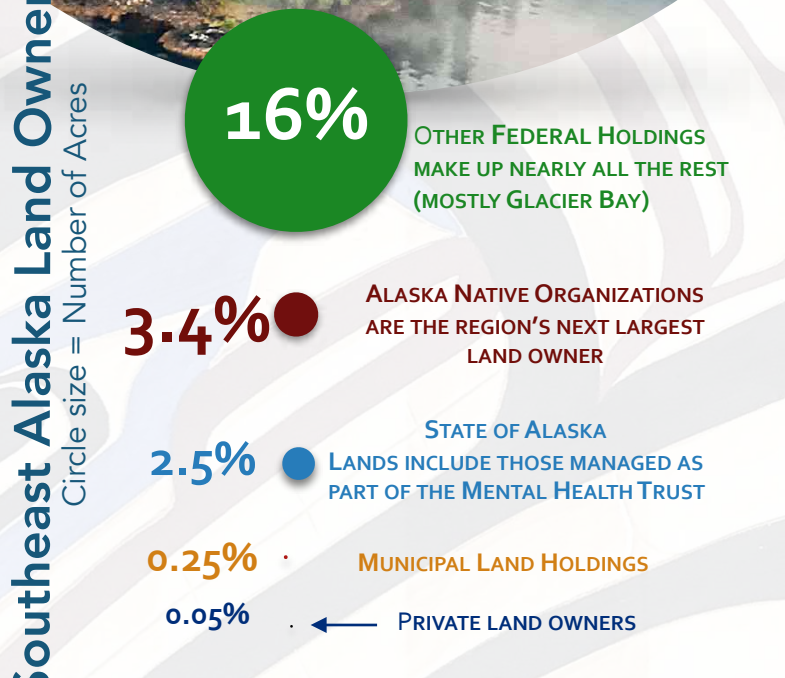
Population losses appear to have leveled out, but uncertainty regarding the state funding cuts makes it hard to project future changes. As long as the state continues to make fiscal reductions, these will continue to be paired with population declines.

Population Change 2014 to 2018

	2014	2018	Change
Juneau Borough	33,000	32,247	-773
Ketchikan Borough	13,889	13,843	-29
Sitka Borough	9,066	8,652	-433
Petersburg Borough	3,198	3,198	-9
Haines Borough	2,551	2,480	-70
Wrangell Borough	2,413	2,426	11
Metlakatla	1,446	1,398	-49
Craig	1,205	1,095	-112
Skagway Borough	1,038	1,088	109
Klawock	803	777	-28
Hoonah	786	789	1
Kake	627	601	-26
Yakutat Borough	623	523	-109
Gustavus	518	554	35
Thorne Bay	530	524	-8
Angoon	420	410	-10
Hydaburg	407	398	-9
Coffman Cove	175	168	-8
Tenakee Springs	129	144	17
Hollis	93	124	31
Naukati Bay	120	124	4
Klukwan	84	94	10
Hyder	91	80	-13
Kasaan	76	81	8
Pelican	77	68	-9
Port Alexander	45	55	10
Edna Bay	47	43	-4
Whale Pass	38	57	17
Port Protection	56	31	-24
Game Creek	18	18	0
Elfin Cove	16	12	-4
Point Baker	12	13	0
Remainder	835	761	-168
Total	**74,432**	**72,876**	**-1,642**

Sources: Alaska Department of Labor (ADOL); ADOL Southeast Alaska Population by Age, Sex and Borough/Census Area, 2010 to 2018; Alaska Population Projections.
Photography credit: Debbie Hart.

SOUTHEAST ALASKA REGIONAL OVERVIEW



THE REGION

The Southeast Alaska panhandle extends 500 miles along the coast from Metlakatla to Yakutat, encompassing approximately 33,500 square miles of land and water. The saltwater shoreline of Southeast Alaska totals approximately 18,500 miles. More than 1,000 islands make up 40 percent of the total land area. The region is home to 34 communities. The three largest communities—Juneau, Ketchikan, and Sitka—together are home to 75 percent of the regional population.

CULTURE

The dominant culture in the region is indigenous. Alaska Natives—the Tlingit, Haida, and Tsimshian—make up nearly a quarter (23%) of the region's population. The Tlingit have resided in the region for 11,000 years. The region's mild climate, abundant food and raw materials supported the development of highly organized and culturally advanced societies with extensive trade routes and rich artwork.

ECONOMIC TRENDS

Starting in the 1880s, the economy of Southeast Alaska experienced a century of growth that intensified after statehood in 1959. From statehood into the 1990s, population and employment levels in Southeast more than doubled as the workforce expanded in the areas of mining, government, fishing, tourism, and timber. In the beginning of the 1990's seafood and timber directly accounted for a fifth of the regional economy. However, over that next decade pulp mills and sawmills in the region closed, laying off 3,200 workers. During the same period, the value of salmon declined and catch levels fell. Total Southeast Alaska wages hit bottom in 1997. The population continued to decline through 2007. Between 2008 and 2015, the region experienced a significant economic recovery, rebounding to record numbers of jobs, wages, and residents. However, the state budget crisis and the loss of more than 800 State of Alaska jobs changed the economic trajectory of the region.

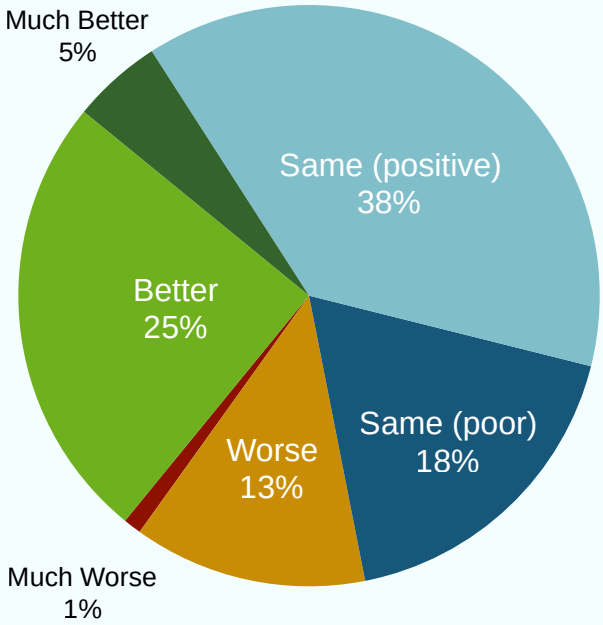
LAND OWNERSHIP

A lack of privately-owned land and land available for development is unique to Southeast Alaska and impacts the ability of the region to nurture the private sector. (See infographic on the left.) Southeast Alaska's land ownership is dominated by the federal government, which manages 94 percent of the land base. Most of this (78%, or 16.75 million acres) is the Tongass National Forest. The remaining federal lands are mostly in Glacier Bay National Park. The State manages 2.5 percent of the total land base (511,500 acres), including the Alaska Mental Health Trust Authority and University of Alaska lands. Boroughs and communities own 53,000 acres—a quarter of one percent of the regional land base. Alaska Native organizations, including village, urban, and regional corporations and the Annette Island Reservation, own 3.4 percent (728,100 acres) of the land base. Other private land holdings account for 0.05 percent of the land base. In 2017, communities received nearly $19 million in federal Payment In Lieu of Taxes and Secure Rural Schools funding to compensate for federal ownership of the regional land base.

Sources: Personal communications with State of Alaska; US Forest Service; Sealaska. *Economies in transition: An assessment of trends relevant to management of the Tongass National Forest, USDA 1998.* **Image Credits:** Misty Fjords Shutterstock image 68855041. Canoe by Annie Caufield. Background image carving by Mike Dangeli.

SOUTHEAST **ECONOMIC OUTLOOK** SURVEY

"What is the economic outlook for your business or industry over the next year (compared to the previous year)?"



Current Regional Business Climate Survey

In April of 2019, 320 Southeast Alaska business owners and top managers from 25 communities responded to Southeast Conference's Business Climate and Private Investment Survey.

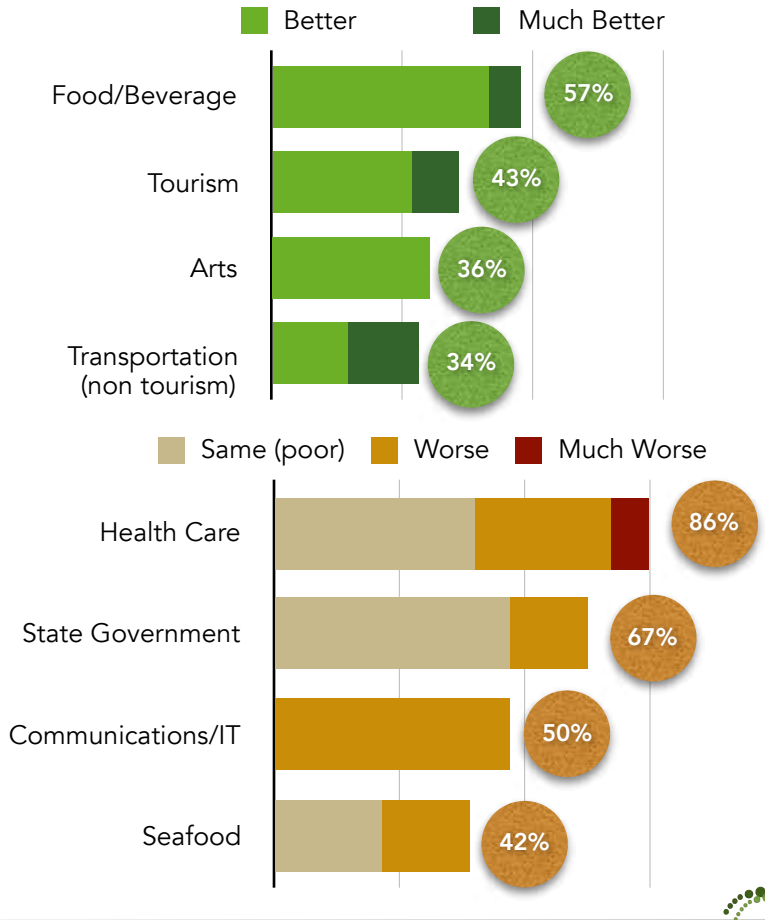
Southeast Alaska Economic Outlook

Southeast Alaska business leaders overall have a similar outlook looking forward that they did a year ago. More than half (56%) of survey respondents expect their prospects to remain status quo, 30% expect their prospects to improve in the coming year, and 14% expect decline. This represents a one percent increase in overall positive outlook over last year, but a three percent increase in those who feel the outlook is "much better" than it was the year before.

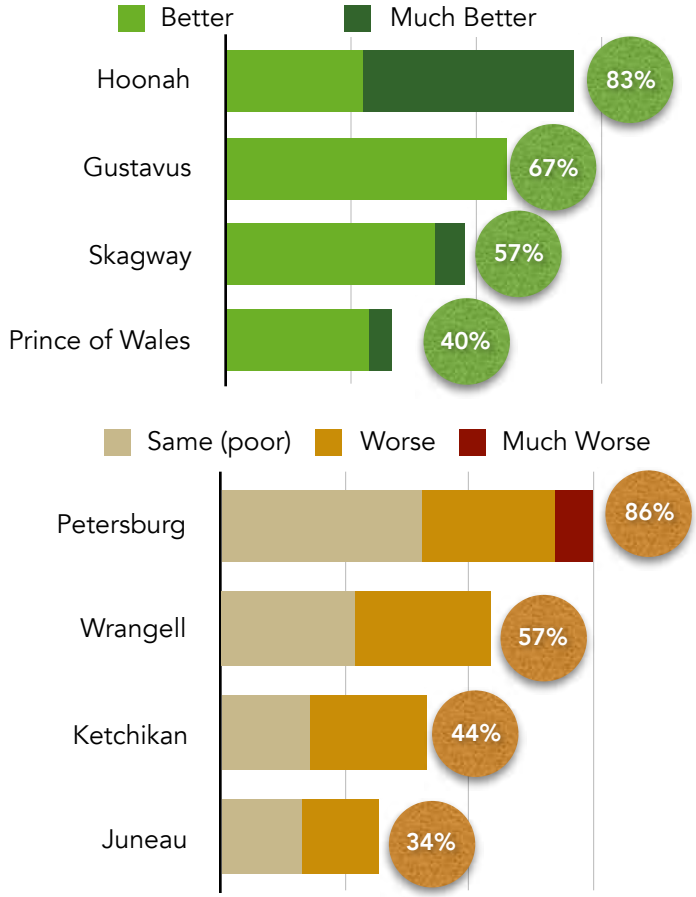
Businesses in Hoonah, Gustavus, and Skagway reported the outlooks that are most likely to improve — more than 50% of business leaders in each of those communities said that they expect the economic outlook to be better or much better in the next 12 month. Petersburg leaders reported the most deteriorating economic outlook. The food and beverage, and tourism industries reported the most improving outlooks by industry, with more than 40% of respondents foreseeing improvement. The least optimistic sector was the health care industry; 43% of respondents expect that industry to worsen.

What is the economic outlook for your business or industry compared to last year?

By Industry

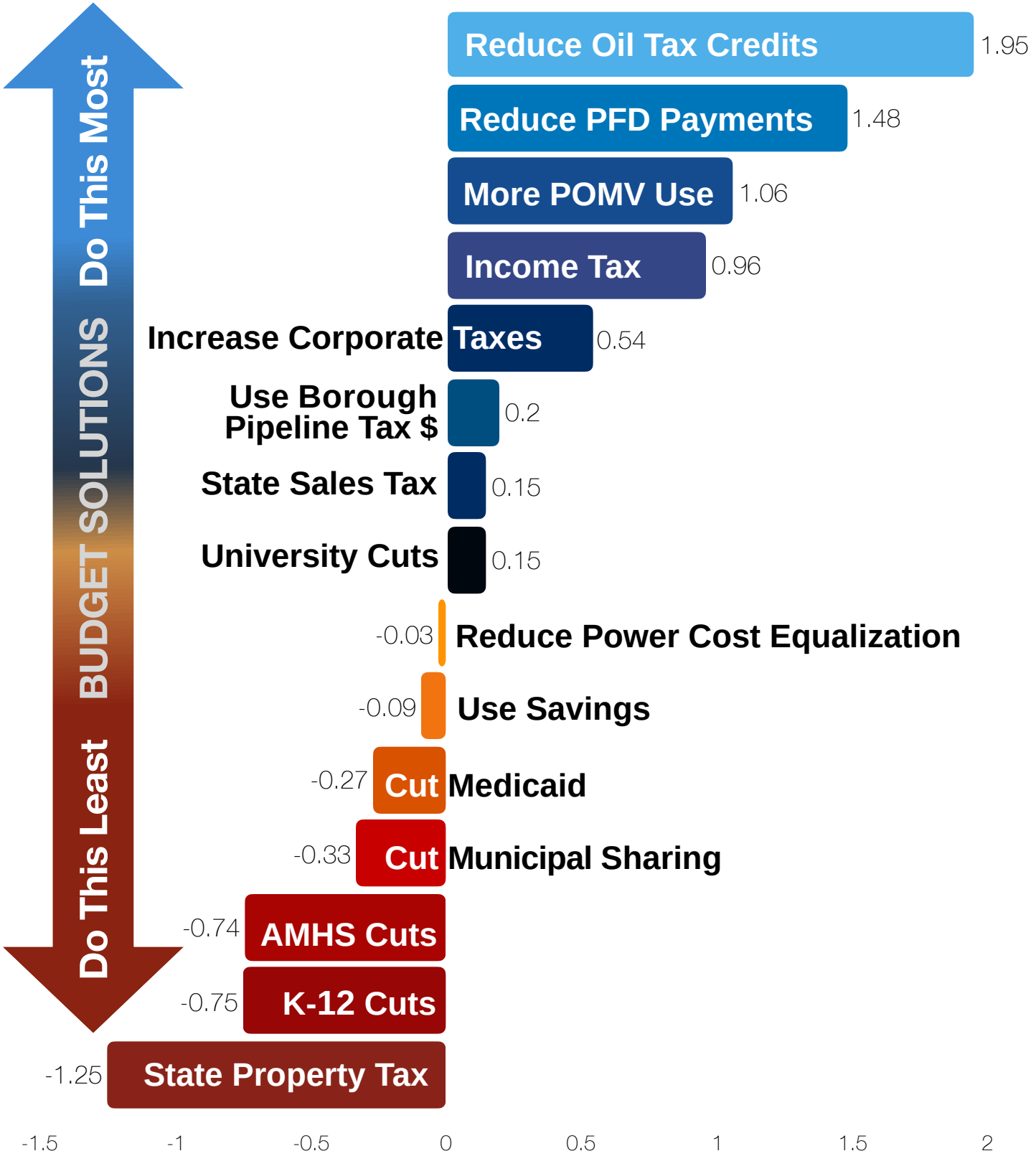


By Community



Southeast Businesses **Budget Findings**

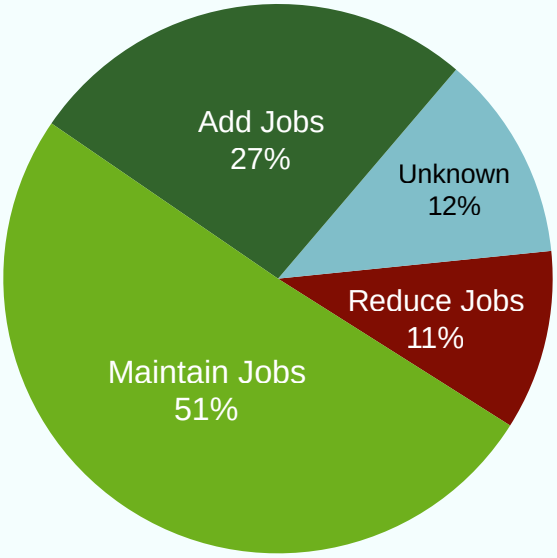
Southeast Conference asked **320** Southeast business owners and top managers in **25** regional communities how they would like to see the state achieve a balanced budget. This is an overall ranking of their responses.



Responses weighted by use preference

Adding **Jobs in 2019 and 2020**

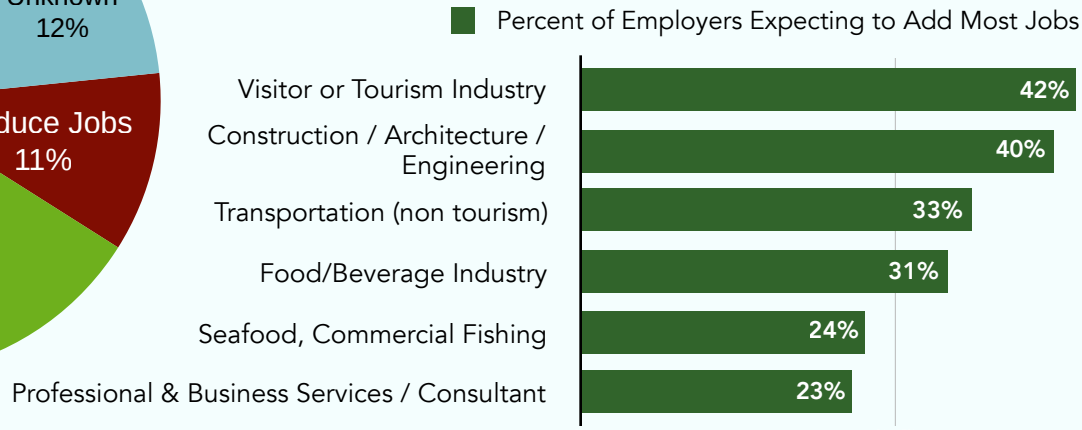
Over the next year, do you expect your organization to add jobs, maintain jobs, reduce jobs, or are you unsure?



Hiring in the next year

A new question added to the survey this year was regarding hiring expectations over the next year. More than a quarter of the 320 business leaders surveyed expect to add jobs to their businesses over the next 12 months, while 51% expect to maintain total jobs, and 11% expect to reduce total employees. The largest gains are expected in the visitor industry, where a staggering 42% of respondents expect to increase their total staff in the upcoming year. The arts, IT, financial, and real estate sectors project the smallest worker increases.

Analyzed by community, Skagway employers expect the most significant job gains. Juneau and Petersburg are the least likely to add jobs next year.



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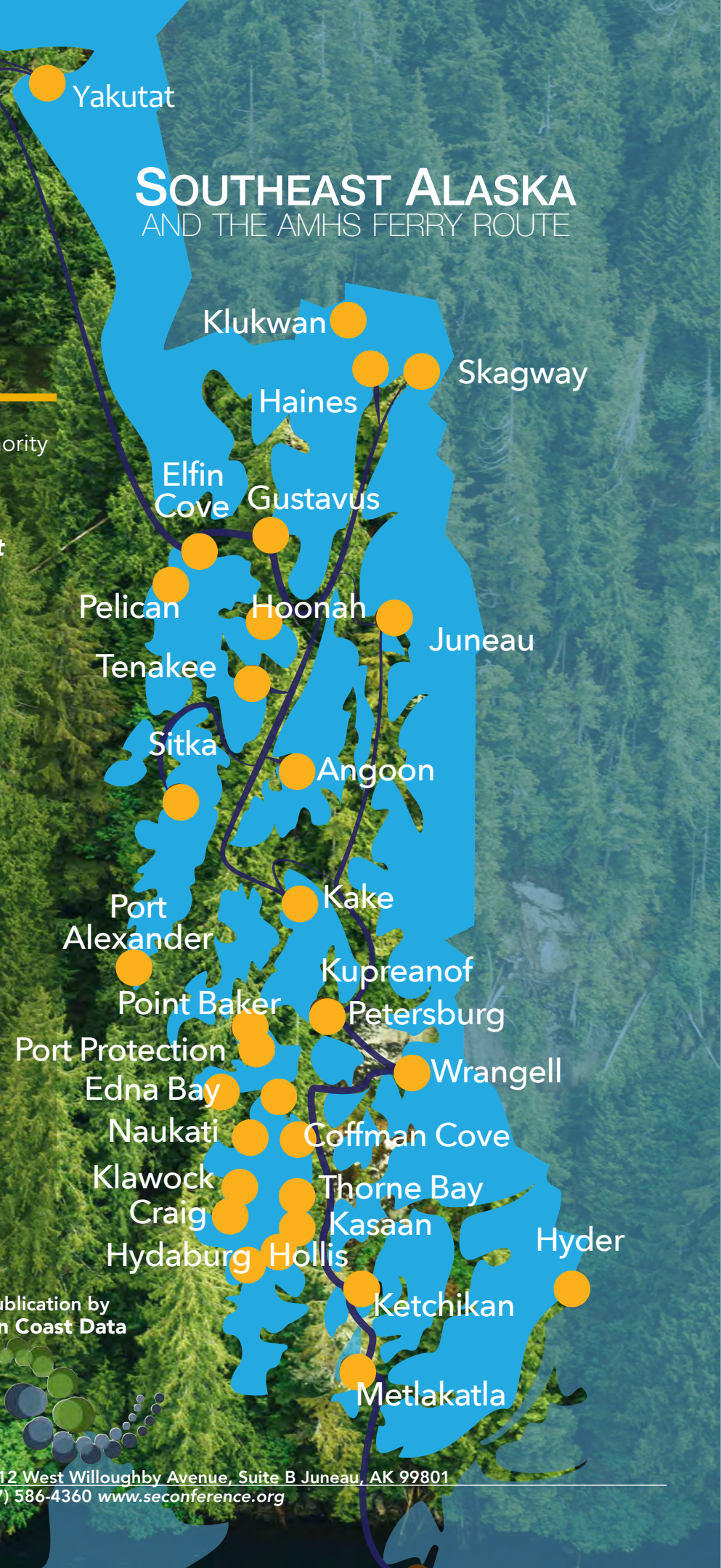

Southeast Conference 612 West Willoughby Avenue, Suite B Juneau, AK 99801
(907) 586-4360 *www.seconference.org*

SOUTHEAST ALASKA CONSERVATION COUNCIL - DEFENDERS OF WILDLIFE CENTER FOR BIOLOGICAL DIVERSITY – EARTHJUSTICE ALASKA OFFICE – AUDUBON ALASKA - SITKA CONSERVATION SOCIETY – WOMEN'S EARTH AND CLIMATE ACTION NETWORK

September 16, 2019

Carey Case, Project Leader
Petersburg Ranger District
P.O. Box 1328
Petersburg, AK 99833
Via email: carey.case@usdoj.gov
Via web portal: https://cara.ecosystem-management.org/Public/CommentInput?Project=53098

Re: Comments on Central Tongass Project Draft Environmental Impact Statement

Project Leader Carey Case:

The U.S. Forest Service is analyzing the Central Tongass Project (the Project) and has prepared a Draft Environmental Impact Statement (DEIS). The undersigned organizations submit these comments on the Central Tongass DEIS. These groups have a long-standing interest in the social and ecological values of the Tongass National Forest and any developments that may affect those values. For the reasons described below, the Forest Service should not pursue the logging aspects of the Central Tongass Project.

This Central Tongass Project is a proposal under the 2016 Amended Forest Plan, to authorize logging up to 230 million board of Tongass timber, 150 million board feet from old-growth forests and 80 million board feet of young growth, over the next 15 years from somewhere inside the Petersburg and Wrangell Ranger Districts – a 3.7 million acre project area. The project also calls for building up to 25 miles of new road and 93 miles of temporary road, and approving 128 miles of off-highway vehicle trails on roads currently closed or planned for closure.

The Central Tongass Project is the agency's latest attempt to authorize large, multi-year projects without any consideration of impacts to specific resources. This is precisely the type of environmentally blind decision-making Congress intended the National Environmental Policy Act (NEPA) to avoid when it enacted this bulwark against hasty and wasteful agency actions. As a result, neither the Forest Service nor the public can adequately analyze the site-specific impacts and alternatives proposed and make a reasoned choice among the alternatives. The Forest Service is now defending this very type of flawed decision before the Alaska Federal District Court in *Southeast Alaska Conservation Council et al. v. U.S. Forest Service et al.*, Case No. 1:19-cv-00006-SLG.

To fulfill NEPA's twin aims of informed agency decision-making and public participation, the Forest Service must provide a detailed statement of the impacts of agency activity. The Forest Service lacks the discretion to determine what level of specificity NEPA requires.

The agency violates NEPA by disclosing only conditions for treatment rather than site-specific information about logging, roadbuilding, or where herbicides will be used until sometime in the future – after the agency has authorized those activities and after the public has any chance to object to the decision. This violates NEPA. Without providing the public with information about the specific location of proposed logging and roads within the 3.7 million-acre project area, the Forest Service fails to provide the detailed assessment of impacts that NEPA requires. The information provided for public review conveys next to nothing about what activities might actually happen, when, or where, and how those activities will affect wildlife, salmon, and people, or what the alternatives might minimize those impacts.

The level of detail provided to the public in the Central Tongass draft environmental impact statement is of little or no value to subsistence users because subsistence activities are inherently location-specific. People care about the places they use for subsistence and how the action will affect those places and nearby habitat. Displaying one giant map covering millions of acres, of which nearly 9,500 acres of old-growth forest may be logged from anywhere within the about 43,000 acres available for logging, conveys next to nothing about what might actually happen, or how the project will impact wildlife and people, or what the alternatives might be to minimize those impacts.

The proposed action is all the more remarkable given U.S. taxpayers spend tens of millions of dollars every year to subsidize the Tongass timber industry, which contributes a miniscule amount to the regional economy and allows virtually all of the logs to be exported out of Alaska. "The Forest Service reported an average of $12.5 million annually in timber-related expenditures for the Tongass from fiscal years 2005 to 2014. During that period, it reported receiving an average of $1.1 million in revenues associated with timber harvested from the Tongass."[1] "Analyzing the benefits and costs of the Tongass old-growth timber sale program illustrates that beyond being the last industrial scale old-growth logging in the U.S., the Tongass is also the most socially inefficient timber program in the U.S."[2]

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[1] U.S. Government Accountability Office, Tongass National Forest, Forest Service's Actions Related to Its Planned Timber Program Transition at 7 (2016); *see also* Taxpayers for Common Sense, Money Losing Timber Sales: Tongass National Forest at 1 (Mar. 2015) ("From 2008 through 2013, the Forest Service spent $139.1 million on timber sales (including road construction) in the Tongass and received $8.6 million in proceeds from these sales, a net loss of $130.5 million."); U.S. Forest Service, State of the Tongass National Forest (FY 2009 – 2013); Headwaters Economics, The Tongass National Forest and the Transition Framework: A New Path Forward? at 2-5 (Nov. 2014).

The undersigned submit any documents cited in this comment letter (with the exception of statutes, regulations, the 2016 Amended Forest Plan and related documents, documents in the Central Tongass Project planning record, and documents cited in the agency's planning documents) to the Petersburg Ranger District on September 16, 2019 with these comments. These documents are now part of the planning record for the Central Tongass Project.

[2] Hjerpe, E. and A. Hussain, *Willingness to Pay for Ecosystem Conservation in Alaska's Tongass National Forest: a choice modeling study*, Ecology and Society 21(2)8 http://dx.doi.org/10.5751/ES-08122-210208.

For all of these reasons, the Forest Service should not proceed with the logging aspects of the Central Tongass Project. However, if the agency chooses to proceed, then it must prepare and publish a supplementary DEIS that complies with the agency's legal obligations. Today's economic drivers depend upon the forest's old-growth stands to support Southeast Alaska's fish, wildlife, and outdoor recreation industries. Clearcut logging old-growth forests on the Tongass compromises the United States' climate preparedness, and reduces the country's ability to address the effects of climate change worldwide. The logging aspects of the Central Tongass Project represent a wasteful and unsustainable logging program that threatens values important to residents of Southeast Alaska and the nation. We strongly urge the Forest Service to take a different approach with regard to the logging contemplated in the Central Tongass Project.

I. THE CENTRAL TONGASS PROJECT'S USE OF CONDITION-BASED MANAGEMENT VIOLATES NEPA.

A. NEPA Requires The Forest Service To Produce A Spatially And Temporally Specific Analysis Because This Is A Project-level Decision.

In enacting NEPA, Congress recognized the "profound impact" of human activities, including "resource exploitation," on the environment and declared a national policy "to create and maintain conditions under which man and nature can exist in productive harmony."[3] The statute has two fundamental two goals: "(1) to ensure that the agency will have detailed information on significant environmental impacts when it makes decisions; and (2) to guarantee that this information will be available to a larger audience."[4]

To advance these policy objectives, NEPA "establishes 'action-forcing' procedures that require agencies to take a 'hard look' at environmental consequences."[5] A hard look does not allow the agency to take "a soft touch or brush-off of negative effects."[6] By so focusing agency attention, NEPA ensures that the agency will not act on incomplete information, only to regret its decision after it is too late to correct."[7]

In *Natural Resources Defense Council v. U.S. Forest Service*, for example, the Court faulted the Forest Service for providing empty disclosures that lacked any analysis, explaining the agency "d[id] not disclose the effect" of continued logging on the Tongass and "d[id] not give detail on whether or how to lessen the cumulative impact" of the logging.[8] Elsewhere, the Court explained

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[3] 42 U.S.C. § 4331(a).
[4] *Envtl. Prot. Info. Ctr. v. Blackwell*, 389 F. Supp. 2d 1174, 1184 (N.D. Cal. 2004) (quoting *Neighbors of Cuddy Mt. v. Alexander*, 303 F.3d 1059, 1063 (9th Cir. 2002)); *see also Earth Island v. United States Forest Serv.*, 351 F.3d 1291, 1300 (9th Cir. 2003) ("NEPA requires that a federal agency 'consider every significant aspect of the environmental impact of a proposed action . . . [and] inform the public that it has indeed considered environmental concerns in its decision-making process.'").
[5] *Metcalf v. Daley*, 214 F.3d 1135, 1141 (9th Cir. 2000) (quoting *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 348 (1989)).
[6] *Native Ecosystems Council v. U.S. Forest Serv.*, 428 F.3d 1233, 1241 (9th Cir. 2005).
[7] *Marsh v. Or. Natural Res. Council*, 490 U.S. 360, 371 (1989) (citation omitted).
[8] *Natural Res. Def. Council v. U.S. Forest Serv.,* 421 F.3d 797, 812 (9th Cir. 2005).

that "general statements about possible effects and some risk do not constitute a hard look, absent a justification regarding why more definitive information could not be provided."[9] The Forest Service also must provide the public "'the underlying environmental data' from which the Forest Service develop[ed] its opinions and arrive[d] at its decisions."[10] In the end, "vague and conclusory statements, without any supporting data, do not constitute a 'hard look' at the environmental consequences of the action as required by NEPA."[11] "The agency must explain the conclusions it has drawn from its chosen methodology, and the reasons it considered the underlying evidence to be reliable."[12]

At the project level, as compared to a programmatic decision, the required level of analysis is far more stringent.[13] At the "implementation stage," the NEPA review is more tailored and detailed because the Forest Service is confronting "individual site specific projects."[14] Indeed, the Ninth Circuit has faulted the Forest Service for failing to provide site-specific information in a landscape level analysis:

> This paltry information does not allow the public to determine where the range for moose is located, whether the areas open to snowmobile use will affect that range, or whether the Forest Service considered alternatives that would avoid adverse impacts on moose and other big game wildlife. In other words, the EIS does not provide the information necessary to determine how specific land should be allocated to protect particular habitat important to the moose and other big game wildlife. Because the Forest Service did not make the relevant information available . . . the public was limited to two-dimensional advocacy—interested persons could argue only for the allocation of more or less land for snowmobile use, but not for the protection of particular areas. As a result, the Forest Service effectively stymied the public's ability to challenge agency action.[15]

When the Forest Service fails to conduct that site-specific analysis, the agency "does not allow the public to 'play a role in both the decisionmaking process and the implementation of that decision.'"[16] "Although the agency does have discretion to define the scope of its actions, . . . such discretion does not allow the agency to determine the specificity required by NEPA." *City of Tenakee Springs v. Block*, 778 F.2d 1402, 1407 (citing *California v. Block*, 690 F.2d 753, 765 (9th Cir. 1982)). In *State of Cal. v. Block*, for example, the decision concerned 62 million acres

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[9] *Or. Natural Res. Council Fund v. Brong*, 492 F.3d 1120, 1134 (9th Cir. 2007) (citation omitted); *see also Or. Natural Res. Council Fund v. Goodman*, 505 F.3d 884, 892 (9th Cir. 2007) (holding the Forest Service's failure to discuss the importance of maintaining a biological corridor violated NEPA, explaining that "[m]erely disclosing the existence of a biological corridor is inadequate" and that the agency must "meaningfully substantiate [its] finding").
[10] *WildEarth Guardians v. Mont. Snowmobile Ass'n*, 790 F.3d 920, 925 (9th Cir. 2015).
[11] *Great Basin Mine Watch v. Hankins*, 456 F.3d 955, 973 (9th Cir. 2006).
[12] *N. Plains Res. Council, Inc. v. Surface Transp. Bd.*, 668 F.3d 1067, 1075 (9th Cir. 2011) (citation and internal quotation marks omitted).
[13] *See, e.g., Friends of Yosemite Valley v. Norton*, 348 F.3d 789, 800-01 (9th Cir. 2003).
[14] *Forest Ecology Ctr., Inc. v. U.S. Forest Serv.*, 192 F.3d 922, 923 n.2 (9th Cir. 1999).
[15] *WildEarth Guardians v. Montana Snowmobile Ass'n*, 790 F.3d 920, 927 (9th Cir. 2015).
[16] *Id*. at 928 (quoting *Methow Valley Citizens Council*, 490 U.S. at 349).

of National Forest Service Land and the Ninth Circuit still required an analysis of "[t]he site-specific impact of this decisive allocative decision."[17] In short, NEPA's procedural safeguards are designed to guarantee that the public receives accurate *site-specific* information regarding the impacts of an agency's project-level decision *before* the agency approves the decision.

B. The Forest Service's Condition-based NEPA Approach Fails To Analyze The Project's Direct And Indirect Impacts.

Because the Central Tongass Project is a "project-level analysis,"[18] the DEIS is analyzing a site-specific, not a programmatic decision. As a result, the DEIS must include the detailed information and analysis that NEPA and the CEQ regulations require because as the agency makes clear in Chapter 1 of the DEIS, there will not be any further NEPA analysis after this "large landscape-scale NEPA analysis."[19] As discussed below, this approach violates NEPA because the DEIS fails to describe the characteristics of the specific logging and road-building projects (e.g., when, where, how much, what sequence, old-growth versus young-growth, location and length of roads, etc.) and then analyze the direct, indirect, and cumulative impacts from the action alternatives, as well as necessary mitigation associated with implementing decisions.

Because the Forest Service employs condition-based management (although it does not explicitly use that term), the DEIS does not and cannot disclose site-specific impacts until after the decision is made, subverting NEPA's command that agencies look before they leap. The DEIS admits that "[s]pecific locations and methods [of logging, etc.] will be determined *during implementation*," and not before.[20]

For example, in describing timber economics, the DEIS explains that the agency will not define where logging will occur until after NEPA is complete:

> Until the actual units for a timber sale offering are defined, located, and field-reviewed, reductions in acreage and volume cannot be accurately quantified. As described in the Implementation Plan (Appendix A), further refinement of the gross unit pool would be made and a logging plan developed at the time a commercial timber offer is planned.[21]

The problem with timber economics is further compromised given the effect of project falldown during implementation. In discussing methodology and environmental effects with regard to the suitability and gross unit pool development, the DEIS acknowledges that on one island, "there has been a reduction of around 75 percent from the mapped old-growth which defined the gross unit pool for Alternative 2 to the potential [logging] units as identified through recent field

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[17] *California v. Block*, 690 F.2d 753, 763 (9th Cir. 1982).
[18] DEIS at 9.
[19] DEIS at 1.
[20] DEIS at 1 (emphasis added). *See also id.* at i (same); *id.* at 159 ("*During the implementation phase*, careful consideration of timing, location, and characteristics of harvest and roads would minimize adverse effects on aquatic resources.") (emphasis added).
[21] DEIS at 57.

surveys."[22] Please explain whether the acreage estimates of suitable acres disclosed in Tables 7 & 8 of DEIS actually reflect this predicted project-level falldown.

In short, the Forest Service does not know, and cannot analyze or disclose to the public, precisely where logging will occur. As such, the DEIS fails to disclose the project's site-specific impacts. The Forest Service also states:

> *Because it is unknown which acres … will be harvested*, an estimated average volume of 15.8 MBF per acre is assumed for all old-growth harvest acres for this analysis.[23]

Again, the Forest Service's inability to identify the site-specific location for logging, prevents it from taking the hard look NEPA requires.[24]

Similarly, the Forest Service acknowledges that its failure to disclose the location and nature of logging impacts the agency's ability to disclose impacts to scenery.

> With the activities proposed in this project *being general in nature, and not specific with regards to location or appearance*, the scenic analysis is focused on determining if there is capacity within the analysis area and gross unit pool to support the alternatives.[25]

Further reinforcing this conclusion, the Forest Service admits that it will undertake surveys that could inform an impact analysis only *after* the NEPA process is complete.

> Comprehensive stream, rare and sensitive plant, invasive plant, geology, soil, landslide, wetlands, wildlife and cultural surveys *have not been conducted* within the entirety of the project area, but are ongoing throughout the project planning process . . . . It is likely that additional streams, plant populations, karst features, unsuitable soils, landslides, wetlands, nests, dens and cultural sites may be found prior to implementation in currently un-surveyed areas . . . .[26]

The information the Forest Service declined to gather is precisely the information that NEPA and federal courts require the agency to gather, analyze and disclose to the public before the agency approves an action. Failure to provide this information in an EIS renders that document arbitrary and capricious.

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[22] DEIS at 56.
[23] DEIS at 59 (emphasis added).
[24] *See also* DEIS at 64 ("For young growth all harvest is assumed even-aged *because the amount of partial harvest will not be known until implementation of a young-growth timber offering and silvicultural prescriptions are determined*.") (emphasis added); *id*. at 262 (in discussion of impacts to karst resources. stating that: "Until the exact extent and location of any proposed action is determined, *a determination of specific effects cannot be made*.") (emphasis added).
[25] DEIS at 291 (emphasis added).
[26] DEIS at 45 (emphasis added).

II. THE FOREST SERVICE'S FAILURE TO DISCLOSE SITE-SPECIFIC LOGGING AND ROAD INFORMATION IN THE DEIS VIOLATES SECTION 810 OF ANILCA.

ANILCA Section 810 contains procedural requirements parallel to NEPA's: It requires federal land agencies to evaluate the effects of, and alternatives to, any disposition of federal public land on subsistence uses and needs.[27] ANILCA, though, imposes additional requirements beyond the NEPA-like disclosures and analysis. Where the disposition of the land may significantly restrict subsistence uses, the agency must conduct hearings in the project vicinity and make certain findings justifying the restriction.[28] When an EIS is required, the agency must also conduct hearings in affected communities and make substantive findings.[29] Congress enacted Title VIII of ANILCA to "cause the least adverse impact possible on rural residents who depend upon subsistence uses of" federal public lands in Alaska.[30]

Because of the parallel procedural requirements in both statutes, the courts have found NEPA's requirements—including those for site-specificity—apply to the section 810 subsistence evaluations.[31] Section 810's hearing requirements—an obligation not in NEPA—reinforce this conclusion. Where impacts are significant, the agency is required to hold "a hearing in the vicinity of the area involved,"[32] reflecting Congressional recognition of the local nature of subsistence practices.

The DEIS finds "a significant possibility of a significant restriction for the subsistence use of deer."[33] The project area contains three communities spread over 3.7 million acres, 1.8 million of which are in the national forest. Without knowing where the logging will occur, however, it is impossible to convey meaningful information about how the Project may affect their uses. Similarly, site-specific information is needed to make meaningful findings, as required in section 801(a)(3).[34] Under that section, the agency may authorize the action only after determining that:

> (A) such a significant restriction of subsistence uses is necessary, consistent with sound management principles for the utilization of the public lands,

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[27] 16 U.S.C. § 3120(a).
[28] *Id*. § 3120(a)(2)-(3).
[29] *Id*. § 3120(b).
[30] *Id.* § 3112(a); *see Alaska Wilderness Recreation and Tourism Ass'n v. Morrison*, 67 F.3d 723, 725 (9th Cir. 1995).
[31] *See, e.g., City of Tenakee Springs v. Clough*, 915 F.2d 1308, 1310-13 (9th Cir. 1990) (evaluating adequacy of alternatives and cumulative impacts under NEPA and ANILCA together); *Alaska Wilderness Recreation and Tourism Ass'n v. Morrison*, 67 F.3d 723, 731 (9th Cir. 1995) (failure to consider alternatives violated both NEPA and ANILCA); *City of Tenakee Springs v. Clough*, 750 F. Supp. 1406, 1422-23 (D. Alaska 1990) (applying NEPA case law to ANILCA analysis for site-specificity), rev'd on other grounds, 915 F.2d 1308 (9th Cir. 1990).
[32] 16 U.S.C. § 3120(a)(2).
[33] DEIS at 349.
[34] 16 U.S.C. § 3120(a)(3).

(B) the proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other disposition, and

(C) reasonable steps will be taken to minimize adverse impacts upon subsistence uses and resources resulting from such actions.[35]

The DEIS violates ANILCA by attempting to evaluate impacts to subsistence users and resources without identifying where the logging and road building will occur. As all Tongass citizens know, location is critical: each parcel of land is unique, with distinct considerations regarding its management. Consequently, the failure to disclose effects without evaluating location results in an analysis of merely general or generic effects and eliminates the public's ability to compare alternatives based upon their effects. Subsistence is an inherently location-specific activity rooted not only in access to resources, but in human geography, history, and clan relationships. Without an assessment of the specific, local impacts of the proposed action, neither the agency or subsistence users can evaluate the availability of reasonable steps to minimize adverse impacts to subsistence users and resources.

III. THE FOREST SERVICE'S FAILURE TO PROVIDE SITE SPECIFIC INFORMATION VIOLATES NFMA AND THE FOREST PLAN.

The Forest Service violates the National Forest Management Act (NFMA) when it acts contrary to a governing forest plan.[36] Standards established in forest plans "are binding limitations typically designed to prevent degradation of current resource conditions."[37] Thus, "[a] site-specific project must comply with the standards set forth in the governing forest plan, and a project's deviation from a standard requires amendment to the forest plan."[38]

A. The Forest Service Violates Forest Plan Standards Requiring Site-Specific Timber And Road Resource Data, Including Unit Cards And Road Cards.

The 2016 Amended Forest Plan establishes standards that require the Forest Service to provide site-specific information regarding the Central Tongass Project to inform the agency's environmental analysis prior to approval and prevent habitat degradation. The agency violates those standards, rendering the Project unlawful under NFMA. Alternatively, if one or more of these provisions is a guideline, then the agency acts arbitrarily in failing to provide the information prior to approving the Project.

The 2016 Amended Forest Plan defines a "standard" as follows:

> A course of action or level of attainment required by the Forest Plan to promote achievement of goals and objectives.

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[35] *Id*.
[36] *See* 16 U.S.C. § 1604(i) ("Resource plans and permits, contracts, and other instruments for the use and occupancy of National Forest System lands shall be consistent with the land management plans.").
[37] *All. for the Wild Rockies v. United States Forest Serv.*, 907 F.3d 1105, 1113 (9th Cir. 2018).
[38] *Id*.

> A mandatory constraint on project and activity decision-making, established to help achieve or maintain the desired condition or conditions, to avoid or mitigate undesirable effects, or to meet applicable legal requirements. (36 CFR 219.12)[.][39]

It explains that:

> Standards in Chapters 3 and 4, which can usually be identified by words such as 'must' or 'will,' are *mandatory requirements or minimums that must be met*.
>
> Project-level analysis may determine that additional requirements beyond these minimums are necessary.[40]

"The Forest Service must strictly comply with a forest plan's 'standards,' which are considered binding limitations ...."[41] To do otherwise, the agency violates NFMA.

Regarding logging, the 2016 Amended Forest Plan establishes standards that require the Forest Service to assess site-specific conditions, logging impacts, and mitigation and include that information in its NEPA analyses before it approves a project. For example, the Plan states:

> Timber harvest unit cards *will* document resource concerns and protection measures. The unit cards, including a map with relevant resource features, *will be provided electronically when Draft or Final NEPA documents and decisions are published*. (Consult Tongass National Forest Supplement 1909.15-2015-1.)[42]

It also requires the agency to provide other site-specific "timber resource information", including "inventories, analysis of data, and input *for environmental analysis*."[43] It requires the agency to provide information to "[d]etermine operability based on *site-specific project conditions*."[44] The agency must evaluate "management prescriptions . . . within the project area in project design and *environmental analysis* for timber activities."[45] It requires the agency to "[c]omplete all [silvicultural] prescriptions *before* project implementation where implementation is defined as . . . the Final Record of Decision . . . ."[46]

The general area-wide maps or activity guidelines offered by the Forest Service in the Project DEIS fail to meet the Plan requirements because they simply lack the unit specific information

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[39] 2016 Amended Forest Plan at 7-59.
[40] 2016 Amended Forest Plan at 1-4 (emphasis added).
[41] *All. for the Wild Rockies v. United States Forest Serv.*, 907 F.3d 1105, 1110 (9th Cir. 2018); *see also id*. at 1113 (rejecting the Forest Service's argument that its approach was "substantially similar" to the forest plan standard).
[42] 2016 Amended Forest Plan at 4-68 (TIM3.I.C) (emphasis added).
[43] *Id*. at 4-68 (TIM3.I.A) (emphasis added).
[44] *Id*. at 4-68 (TIM3.I.B) (emphasis added).
[45] *Id*. at 4-68 (TIM3.I.C) (emphasis added).
[46] *Id*. at 4-67 (TIM2.C) (emphasis added); *see also id*. at 4-49 (RIP2.C.1.) ("Logging engineers and aquatic specialists should conduct joint reviews of preliminary harvest unit designs to ensure that site-specific stream protection measures meet riparian objectives.").

necessary to meet forest plan standards. The DEIS mentions unit cards only once – to state that such cards will be made available "during final project design," that is, *after* NEPA is completed.[47] According to the Implementation Plan (Appendix A), unit cards are not mentioned until Step 7, after the Responsible Official gives approval to implement (Step 6).[48] Thus, the agency has not: (1) assessed site-specific project conditions and impacts; (2) evaluated site-specific management prescriptions and silvicultural prescriptions; and (3) used that information to inform the agency's environmental analysis and justify its substantive decision-making.

With regard to road construction and reconstruction, the 2016 Amended Forest Plan also establishes standards that inform the environmental review and the agency's decisions. For example, "[d]uring project planning, [the Forest Service must] identify *resource concerns and site-specific mitigation measures*."[49] The 2016 Amended Forest Plan lists specific habitats for which impacts must be minimized.[50] The agency is directed to "[c]learly document these mitigation measures [during project planning] to facilitate project implementation and monitoring."[51] The agency must "[p]erform route or site selection, location, geotechnical investigations, survey, and design to a technical level sufficient to meet the intended use and commensurate with both ecological objectives and the investment to be incurred."[52] "When stream crossings are required to harvest timber," the agency must "assess the environmental effects of road crossings versus yarding corridors, and select the action of least environmental impact where practicable."[53] This the Forest Service has failed to do, violating the Forest Plan, and therefore also violating NFMA. The DEIS's provision of a gross scale map depicting proposed road construction and OHV routes[54] is insufficient for both NEPA and Forest Plan compliance purposes, because those maps make it impossible for the public or the decision-maker to understand the routes' precise location, or the impacts to values along the course of those routes.

The Forest Service also has failed to provide road cards with the DEIS. The agency fails to assess the route and site selection, including the length and character, of any of the roads and fails to demonstrate how those individual decisions are commensurate with the ecological objectives and the investment for any given road approved by the Project. The agency fails to provide the specific road information that the 2016 Amended Forest Plan requires.

In short, the Forest Service violates NFMA by failing to comply with the 2016 Amended Forest Plan's standards governing logging and road building. The Forest Service is required to provide unit and road cards and make other site-specific assessments and evaluations of timber resources, logging and road building impacts, and the necessary mitigation measures to inform the NEPA

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[47] DEIS at v.
[48] *See* DEIS, Appendix A at A-5.
[49] 2016 Amended Forest Plan at 4-77 (TRAN3.I.D).
[50] *See id*. at 4-78 (TRAN4.II.A.); id. at 4-79 (TRAN4.III.A.); id. at 4-91 (WILD1.XIV.A.3.a) ("No road construction is permitted within 600 feet of a [wolf] den unless site-specific analysis indicates that local landform or other factors will alleviate potential adverse disturbance.").
[51] *Id*. at 4-77 (TRAN3.I.D).
[52] *Id*. at 4-77 (TRAN4.I.A.).
[53] *Id*. at 4-51 (RIP.II.E.5).
[54] *See* DEIS Appendix B at B-15.

analysis and *prior* to project approval. By failing to disclose to the public in the DEIS the required site-specific information about proposed activities and their impacts, the agency violates NEPA.[55]

To the extent one or more of the provisions described in this section is a guideline rather than standard, then the Forest Service acts in an arbitrary and capricious manner in failing to comply and provide the information. Failing to provide this information is arbitrary because it violates longstanding agency guidance in the Forest Service Handbook for the Tongass: "Unit and road cards will be provided electronically *when Draft or Final NEPA documents and decisions are published*."[56] The handbook continues: "*For Draft Environmental Impact Statements (DEIS's) . . . completed unit and road shall be published on the project webpage* . . . in bookmarked PDF format for review by other agencies or interested parties *when the NEPA document is published*."[57] Elsewhere the handbook explains that road cards must be developed during the NEPA process to "[d]escribe or display site specific application of required resource protection measure . . . [d]emonstrate field knowledge pertaining to site specific Forest Plan standards and guidelines, [p]rovide a tracking tool for project implementation and monitoring, and [p]rovide road level information for the public and other agencies."[58] The Forest Service provides none of this information and, in so doing, fails to assess the project-level impacts, necessary mitigation, and alternatives prior to authorizing the Project.

Additionally, the Forest Service acts arbitrarily because it is departing from decades of consistent agency practice regarding Tongass management without a reasonable explanation. Prior to the contested Prince of Wales project, the Forest Service prepared site-specific analyses to inform the public and affected communities of the adverse impacts of logging and road building before it approved projects.[59] The 2015 Navy Record of Decision (ROD) recognizes "[t]he unit cards and road cards are an integral part of this decision because they document the specific resource concerns, management objectives, and mitigation measures to govern the layout of the harvest units and construction of roads." [60] Likewise, in 2017, the final ROD for the Wrangell Island Project "incorporat[ed]the project design features and measures to minimize adverse

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[55] *City of Tenakee Springs v. Block*, 778 F.2d at 1407 (citing *California v. Block*, 690 F.2d 753, 765 (9th Cir. 1982)).

[56] FSH 1909.15-2015-1, Environmental Policy and Procedures Handbook, Chapter 10 (Apr. 27, 2015), 13.1 (emphasis added), available at https://www.fs.fed.us/im/directives/field/tongass/fsh/1909.15/1909.15_13-2015_TNF.docx (last viewed Sept. 16, 2019). The handbook states: "This supplement is effective until superseded or removed."

[57] FSH 1909.15-2015-1, Environmental Policy and Procedures Handbook, Chapter 10 (April 27, 2015), 13.1 (emphasis added); *see also id*. at 13.2c (directing the Forest Service to "display unit-specific information necessary for project implementation on one unit card map representing the selected alternative or alternatives in a DEIS").

[58] FSH 1909.15-2015-1, Environmental Policy and Procedures Handbook, Chapter 10 (Apr. 27, 2015), 13.3.1-4; *see also id*. at 13.3a, c-e.

[59] *See, e.g.*, Big Thorne DEIS, Vol. III (Unit Cards 1-120), IV (Unit Cards 121-476), V (Unit Cards 500-582), VI (Road Cards); Big Thorne FEIS, Appendix C; Logjam DEIS, Appendix B (Unit Cards); Logjam DEIS, Appendix C (Road Cards); Logjam FEIS, Appendix C.

[60] Navy ROD at 1 (Aug. 11, 2015).

environmental effects of the Selected Alternative . . . . These are described in chapter 2 of the FEIS and in the unit cards and road cards (appendices 1 and 2 of this ROD.)"[61] In describing the effects common to all Action Alternatives, the DEIS for the Wrangell Island Project states "[s]ite-specific resource concern and design criteria are discussed in the road and unit cards."[62] In contrast, the Central Tongass Timber Project will not prepare unit and road cards until Step 7 of the Implementation Plan, after the Responsible Official approves activity implementation.[63] For this additional reason, the Forest Service acts arbitrarily under NFMA because it provides none of that information to explain and justify its decision.

In sum, the 2016 Amended Forest Plan requires the Forest Service to conduct a site-specific assessment, analysis of impacts and mitigation measures relating to logging and road activities to inform the NEPA review and *before* it approves the Central Tongass Project. The agency is violating those provisions and, as a result, violates NFMA. For the same reason, the Forest Service reaches arbitrary conclusions under the other statutes governing timber sale projects on the Tongass.

B. The Forest Service's Condition-Based Analysis Renders Its Decision-Making Arbitrary Under NFMA And The Other Laws Governing Timber Sales.

NFMA and the other statutes under which the Forest Service operates when the agency evaluates a timber sale project require the agency to balance logging objectives with other forest values such as wildlife, recreation, and subsistence.[64] Here, the Forest Service acts arbitrarily because the agency fails to explain when, where, and how the logging and road building authorized by the Project will occur and how the agency balances competing uses and interests in those locations and at a given time. Stated more directly, the agency fails to balance the adverse impacts caused by logging or road building in any particular location at any given time, rendering the conclusions regarding the balance of impacts and values arbitrary. Any balancing based on this record cannot have taken into consideration the kind of site and temporally-specific information about impacts and alternatives that must underlie those choices.

The Administrative Procedure Act (APA) requires that "the agency must examine the relevant data and articulate a satisfactory explanation for its action including a 'rational connection between the facts found and the choice made.'"[65] A decision is arbitrary if the agency "entirely failed to consider an important aspect of the problem" or "offered an explanation for its decision

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[61] Wrangell Island Project ROD at 1 (Nov. 12, 2017).
[62] Wrangell Island Project DEIS at 147.
[63] Central Tongass DEIS, Appendix A at A-5.
[64] *See* 16 U.S.C. § 1604(e) (National Forest Management Act); *id*. § 529 (Multiple-Use Sustained-Yield Act); *id*. § 539d(a) (Tongass Timber Reform Act); id. § 3120(a)(3)(A) (Alaska National Interest Lands Conservation Act); *see also Natural Res. Def. Council*, 421 F.3d at 808-09 (explaining balancing of timber and other goals in the Tongass).
[65] *Motor Vehicle Mfrs. Ass'n of the U.S. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983) (quoting *Burlington Truck Lines v. United States*, 371 U.S. 156, 168 (1962)).

that runs counter to the evidence before the agency."[66] Similarly, an action may be arbitrary if the record does not support the agency's reasoning.[67]

The Forest Service's failure to conduct a spatially and temporally specific analysis means the agency's conclusions lack a rational connection regarding the impacts and tradeoffs of the Central Tongass Project. The agency's decision-making also ignores important aspects of the Project (*e.g.*, site-specific impacts, alternatives, etc.), fails to provide a rational connection between the facts found and the decision to proceed, and offers an explanation that runs contrary to the evidence. As such, any Forest Service decision to approve the Central Tongass Project based on the current condition-based analysis would be arbitrary and unlawful under NFMA and the other statutes governing timber sale projects

IV. THE CENTRAL TONGASS DEIS FAILS TO ANALYZE A RANGE OF REASONABLE ALTERNATIVES.

"Under NEPA's applicable regulations, a federal agency's EIS must '[r]igorously explore and objectively evaluate *all* reasonable alternatives [to a proposed action], and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.'"[68] As the courts have made clear: "The agency must look at *every* reasonable alternative within the range dictated by the nature and scope of the proposal. The existence of reasonable but unexamined alternatives renders an EIS inadequate."[69] An agency's consideration of alternatives becomes meaningless if the agency arbitrarily constrains the range of alternatives considered and fails to consider alternatives that avoid the adverse effects of the proposed action, frustrating NEPA's goal of protecting the environment.[70] As explained below, the DEIS violates NEPA because the Forest Service fails to analyze reasonable alternatives to the Central Tongass Project.

A. The Forest Service's Condition-Based Analysis Fails to Consider Site-Specific and Temporal Alternatives.

The Central Tongass Project is a single decision to authorize numerous logging projects and road construction across vast swaths of Mitkof, Kupreanof, Kuiu, Wrangell, Zarembo and Etolin islands and parts of the U.S. mainland over a 15-year period. The DEIS violates NEPA because it fails to examine reasonable alternatives to the location, timing, sequencing, and sizes of the specific logging and road construction activities the decision will authorize.

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[66] *Id*. at 43.
[67] *See, e.g.*, *Ctr. for Biological Diversity v. NHTSA*, 538 F.3d 1172, 1201-03 (9th Cir. 2008); *Pac. Coast Fed'n of Fishermen's Ass'ns v. NMFS*, 265 F.3d 1028, 1037-38 (9th Cir. 2001).
[68] *Se. Alaska Conservation Council v. Fed. Highway Admin*., 649 F.3d 1050, 1056 (9th Cir. 2011) (quoting 40 C.F.R. § 1502.14(a)) (emphasis added).
[69] *'Ilio'ulaokalani Coal. v. Rumsfeld*, 464 F.3d 1083, 1095 (9th Cir. 2006) (emphasis added); *see also Se. Alaska Conservation Council*, 649 F.3d at 1056 (courts "have repeatedly recognized that if the agency fails to consider a viable or reasonable alternative, the EIS is inadequate.").
[70] *See Kootenai Tribe of Idaho v. Veneman*, 313 F.3d 1094, 1123 (9th Cir. 2002); *California v. Block*, 690 F.2d 753, 765-69 (9th Cir. 1982).

Given the Forest Service's reliance on the condition-based analysis, the agency never describes the precise location, configuration, sizes, and timing of the logging and road construction activities. The DEIS reiterates that the details regarding the logging will only come after the agency approves the Central Tongass Logging Project:

> No alternative would harvest all potential stands identified within the gross unit pool. Only the acreage needed to meet alternative volume would be harvested. Not all roads in the gross unit pool would be constructed, only those needed for access to harvest the selected stands.[71]

Thus, because the Forest Service will not make decisions about when, where, and how much habitat will be logged (or which or where roads will be built) until after completion of the NEPA process, the DEIS fails to analyze alternatives to those specific logging and road construction activities.[72] For example, the Forest Service fails to examine the impacts and alternatives to logging any particular watershed or forgoing logging in favor of improved habitat connectivity in a particular location. Similarly, the agency fails to examine variations in the timing of the logging projects and the sequencing of timber sale projects on any particular portion of the Central Tongass project area (*e.g.*, will a given area experience repeated years of adverse impacts, etc.). The DEIS also fails to consider whether the agency will allow a particular sale for export as compared to domestic processing (*e.g.*, might a smaller logging project in a particular area support a larger number of Alaskan jobs with fewer adverse impacts). With regard to roads, the DEIS fails to analyze the impacts of alternatives to particular roads and routes (*e.g.*, building a permanent road versus a temporary road in any particular location, varying lengths and locations of that road, timber operators paying for the roads instead of taxpayers, etc.). Finally, with the exception of the minor differences between Alternatives 2 and 3, the DEIS fails to examine the site-specific impacts on communities and subsistence users arising from alternative locations, sizes, and timing of any particular timber sale project and road building.

The Forest Service violates NEPA by refusing to examine alternatives to individual logging and/or road construction projects in the DEIS (*e.g.*, location, distribution, connectivity, sizes, characteristics, timing, etc.). The agency's all or nothing approach skews the consideration of alternatives in favor of the environmentally-damaging generic logging and road building alternatives, entirely frustrating NEPA's goals of fostering informed decision making and protecting the environment.[73] In so doing, the Forest Service violates NEPA.

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[71] DEIS at 56. *See also id.* at 360 (same).

[72] *See* DEIS at 1 ("Specific locations and methods [of project activities] will be determined during implementation").

[73] *See Kootenai Tribe*, 313 F.3d at 1123 (NEPA's purpose "is first and foremost to protect the natural environment"); *Block*, 690 F.2d at 765-69 (9th Cir. 1982) (considering a range of alternatives becomes meaningless if the range is skewed by arbitrary constraints).

B. The Forest Service Fails To Analyze Different Action Alternatives To Achieve The Transition Outlined In The 2016 Amended Forest Plan.

SEACC and others requested the Forest Service to consider an alternative "that focuses on supplying timber, both young and old-growth, for value-added industries in a steady supply of micro and small sales for local entrepreneurs."[74] The agency declined to do so, asserting that such an alternative "could not meet the purpose and need for the . . . Project" and "would not meet the requirement of the TTRA [Tongass Timber Reform Act] to seek to provide a supply of timber which meets the annual demand *even in conjunction with other Tongass timber projects*."[75] The agency's reasoning is arbitrary for several reasons.

First, the purpose and need chosen by the agency does not prescribe a timber target for the Central Tongass Project. Consequently, any supply of timber offered from this project would contribute to meeting market demand for Tongass timber. Moreover, it is arbitrary to conclude that each of the several ongoing timber development projects on the Tongass, must be sufficient, on its own to satisfy so-called demand estimates calculated annually and over the planning cycle for Tongass timber. The TTRA does not require each timber sale to meet some inflexible supply level "but a balancing of the market, the law, and other uses, including preservation."[76]

With regard to young growth, the Forest Service recently completed the most expansive young forest inventory ever conducted on the Tongass. The agency inventoried over 40,000 acres of young growth, supplemented by data supplied by the Geos Institute, and combined with inventory data collected by the Forest Service Pacific Northwest Research Station. Collectively, these inventories uncovered a 'wall of wood' soon available to support an appropriately scaled forest industry without industrial logging of old growth or developing additional roadless areas.

Recent analysis of the updated young growth inventory data indicates that the Forest Service can begin sustainably logging second growth, now. The analysis was compiled by Mater Engineering in *Tongass in Transition: 2019 Update*.[77] The report identified 138,760 acres stocked with young trees now 55 to 70-years old in suitable (low environmental risk) areas located within 800 feet of existing and open Forest Service roads and at less than 1,000 feet in elevation. This data clearly shows the transition to logging only young growth is currently possible on the Tongass. If the Forest Service is truly serious about a continued logging industry in Southeast Alaska, it is more evident than ever that young growth is the answer. As a result, the timber industry in Southeast Alaska can immediately stop the controversial practice of industrial-scale old-growth clearcutting.

Existing mills in the region will need to retool to handle the emerging smaller diameter young growth logs instead of old growth logs. Capital for needed renovations could come from public and private funding. After 3 years of project design and field work by the Forest Service

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[74] *See* SEACC scoping comments at 3 (AR 832_0304); *see also* AR 832_0171 (Petersburg Economic Development Council).
[75] DEIS at 26 (emphasis added).
[76] *AWRTA v. Morrison,* 67 F.3d 723, 731 (9th Cir. 1995).
[77] Mater Engineering, *Tongass in Transition: 2019 Update*.

Research Station, paid with congressional funds secured by Senator Murkowski, the next step is to establish a young growth wood quality pilot mill to test for lumber grade recovery and market demand.

According to the DEIS, "[t]he [Timber Analysis Areas] with the best opportunities for positive-appraising young-growth timber sales are Thomas Bay, Mitkof Island, Zarembo and western Kupreanof."[78] This information is consistent with the latest inventory findings, and supporting analysis.[79] The Forest Service inventoried 563 acres of 50-54 year old stands at an estimated volume of 26 mbf/acre. The Pacific Northwest Research Station estimate showed 24 mbf/acre.

The Forest Service violates NEPA because the DEIS fails to examine alternatives that implement the 2016 Amended Forest Plan's objective to transition the Tongass away from a predominant old-growth industry. As explained below, the agency fails to consider a range of alternatives that result in significant variation in the amount and timing of old-growth timber sales over the 15 years from the project area.

The Forest Service adopted the 2016 Amended Forest Plan in response to the Secretary of Agriculture's Memorandum 1044-009,[80] which directed the Tongass National Forest "to expedite the transition away from old-growth timber harvesting and towards a forest products industry that uses predominantly second-growth . . . forests."[81]

The 2016 Amended Forest Plan contains several objectives to accomplish the Secretary's directed transition, including:

- "**O-YG-01:** During the 15 years after plan approval, the amount of young-growth offered would gradually increase to exceed 50 percent of the timber offered annually."[82]

- "**O-YG-02:** During the 15 years after plan approval, offer increasing annual volumes of economically viable young-growth timber. Old-growth timber harvest would gradually be reduced to an average of 5 million board feet (MMBF) annually, to support Southeast Alaska mills."[83]

The 2016 Amended Forest Plan makes clear that "[s]pecific activities and projects will be planned and implemented to carry out the direction in this Forest Plan."[84]

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[78] DEIS at 69.
[79] *See supra* Mater Engineering, *Tongass in Transition: 2019 Update*.
[80] 2016 Amended Forest Plan FEIS at 1-8 to 1-9; *see also* PR 769_01_000046 at PDF 1 (U.S. Department of Agriculture, Office of the Secretary, Secretary's Memorandum 1044-009 Addressing Sustainable Forestry in Southeast Alaska at 1-5 (July 2, 2013)) (Secretary's Transition Memorandum).
[81] 2016 Amended Forest Plan FEIS at 1-9; *see generally* Secretary's Transition Memorandum.
[82] 2016 Amended Forest Plan at 5-2.
[83] *Id*. at 5-3.
[84] *Id*. at 1-2.

Groups raised several concerns regarding the Forest Plan FEIS and its consideration of alternatives at the forest plan stage.[85] Among those concerns, groups explained that all of the alternatives in the 2016 Amended Forest Plan FEIS offered the same purported transition out of old-growth logging to bring about the transition, including: (1) all of the action alternatives lacked any means of limiting old-growth timber sales to bring about the transition; (2) all of the action alternatives offered 10-15 years transition timeframes; (3) all of the action alternatives established a projected timber sale quantity of 46 MMBF per year; and (4) all of the alternatives contemplated continued application of the Limited Export Policy.[86] The undersigned reiterate these concerns given the Forest Service's project-level decision-making manifests these failings.

Now at the implementation stage, the Forest Service again fails to consider any alternatives that contemplate different approaches to the transition regarding the Central Tongass Project (*e.g.*, limiting the amount of old-growth logging *every year* on a declining basis, etc.). Both of the action alternatives are based on the same market demand projections, despite the fact the agency itself acknowledges it cannot predict future market demand with any degree of reliability more than a few years out.[87] And finally, both of the action alternatives apparently contemplate the same treatment with regard to the Limited Export Policy.

The Forest Service also arbitrarily rejects calls to evaluate alternatives that would offer no old-growth sales, as well as an alternative that "focuses supplying old- and young-growth timber through microsales or small sales only."[88] In rejecting the "no old-growth" alternative, the DEIS states: "Commercial old-growth harvest is part of the purpose and need because the Tongass National Forest managers are obligated to seek to meet demand for timber from the forest to comply with the Tongass Timber Reform Act (TTRA Section 101)."[89] But the TTRA does not mandate old-growth logging. Instead, it provides:

> (a) Subject to appropriations, other applicable law, and the requirements of the National Forest Management Act of 1976 (Public Law 94-588), except as provided in subsection (d) of this section, the Secretary shall, *to the extent consistent with providing for the multiple use and sustained yield of all renewable forest resources*, seek to provide a supply of timber from the Tongass National Forest which (1) meets the annual market demand for timber from such forest and (2) meets the market demand from such forest for each planning cycle.[90]

This provision does not mandate the sale of any forest type, let alone old-growth. It also clearly grants the Forest Service the discretion to find that protecting old-growth serves the agency's multiple use mandate better than liquidating carbon stores, wildlife habitat and America's (and tribes') natural heritage.

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[85] *See* SEACC et al. Forest Plan Objection at 12-19, 29-40 (Aug. 30, 2016).
[86] *See id.* at 12.
[87] DEIS at 58.
[88] *Id.* at 25, 26.
[89] *Id.*
[90] 16 U.S.C. § 539d(a) (emphasis added).

The DEIS also states that "the Forest Plan authorizes old-growth harvest as a means to help the forest industry and other stakeholders remain financially viable during the transition to predominantly young-growth timber harvest."[91] But simply because the Plan permits old-growth harvest does not mean that *this* project must be used to fulfill *all* (or even some) of the Plan's proposed logging in the project area, as Alternative 2 would do.[92] The DEIS's summary dismissal of the old-growth protection alternative is arbitrary and capricious.

In short, the Forest Service violates NEPA because the DEIS and 2016 Amended Forest Plan Final EIS unlawfully analyze only action alternatives that depend on clearcutting old growth. As the Ninth Circuit has explained, agencies cannot make an informed decision on a project's environmental impacts when "[t]here is no meaningful difference between the . . . alternatives considered in detail[.]"[93] The Forest Service's failures render the DEIS and the 2016 Amended Forest Plan Final EIS unlawful under NEPA.

V. The DEIS's Action Alternatives Are Too Similar.

The DEIS also violates NEPA because the two action alternatives are too similar to one another in fundamental ways with regard to most project elements, including logging and road construction.

For example, the two action alternatives – 2 and 3 – are identical in terms of their proposals for: stream, lake shore, and floodplain restoration; fish improvements; invasive plant treatments; 45,000 acres of young-growth "silvicultural intermediate treatments;" fish passage; marine access facilities; recreation facilities; and the construction of up to 300 miles of pedestrian trails.[94] Further, the differences in terms of logging, road construction, and related activities are small. Alternative 3 proposes only modest reductions from the maximum development proposed under Alternative 2. Specifically, when compared to Alternative 2, Alternative 3 would:

- log 87.4% of the total timber volume (84.7% of the old growth and 92.5% of the young growth);
- log 86.9% of the total acreage;
- log 89.5% of the total acres of old- and young-growth on karst;
- construct 88% of the new road miles and 88.2% of the temporary road miles; and

[91] DEIS at 26.
[92] *See* DEIS at iv ("Timber offered for purchase is expected to total a maximum of 150 MMBF of old-growth timber and 80 MMBF of young-growth timber for a total volume of 230 MMBF over 15 years over the entire project area"); *id*. at 58 ("The 2016 Forest Plan estimates approximately 150 MMBF of old-growth timber and 80 MMBF of young-growth timber harvest during the first 15 years, from lands suitable for timber production within the Petersburg and Wrangell Ranger Districts").
[93] *W. Watersheds Project v. Abbey*, 719 F.3d 1035, 1051 (9th Cir. 2013).
[94] DEIS at 28, 29.

- construct 100% of the total road miles on karst.[95]

In short, the DEIS considers no middle-ground action alternative, only two alternatives that are essentially similar in many ways and differ only at the margins in terms of logging and road building. NEPA requires the Forest Service to examine meaningful differences between the action alternative and other alternatives. The agency should examine differences in the sizes of individual sales, the locations of those sales, and the timing and sequence of the sales. The lack of substantial variation among the alternative components proposed in the DEIS violates NEPA.

VI. ALTERNATIVES FAIL TO ADDRESS IMPLICATIONS OF, AND ALTERNATIVES TO, DECISIONS TO ADOPT AND IMPLEMENT THE EXPORT POLICIES.

The Forest Service's decision to adopt various versions of the Export Policy has had direct environmental effects because the agency admits it increases the volume of logging on the Tongass, thereby increasing adverse environmental impacts, while decreasing the number of jobs created per unit of timber cut. The Export Policy has, however, never been subject to NEPA review or public notice, review and comment pursuant to the APA. By attempting to evade public review of the adoption and implementation of these policy decisions at both the forest plan and project level, the Forest Service is acting contrary NEPA, NFMA, and the other timber sale statutes governing timber sale decisions.

As explained in SEACC's objections to the 2016 Amended Forest Plan,[96] the Forest Service violated NEPA because the Forest Plan FEIS fails to disclose and analyze the significant environmental and economic impacts of the agency's decisions to adopt export policies. The agency's decisions to adopt various export policies also raises infirmities under NFMA and the other statutes under which the Forest Service operates, as the decisions directly influence the agency's ability to balance multiple competing interests when managing the national forests, including the agency's decision to select an alternative that maximizes the amount of large-scale old-growth logging approved.[97] The undersigned incorporate those previous arguments in their entirety.

At the project level, the "Current Region 10 Export Policy" has a significant, if not the most important, impact on the likelihood that timber sales allowed under various alternatives could be sold and, therefore, on the environmental impacts of the Central Tongass Project. Thus, it has a direct effect on the environmental impacts and economic impacts for Southeast Alaska and, as a result, the Forest Service must evaluate and disclose those impacts in a new DEIS. This analysis should also consider the impacts of the trade war with China on the Alaska industry, and the difficulties of tariffs on Alaska's market share (1 percent).[98] In particular, will the uncertainty

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[95] DEIS at 27 (Tables 2).
[96] *See* SEACC Forest Plan Objection at 25-35.
[97] *See* 16 U.S.C. § 1604(e) (NFMA); *id*. § 529 (Multiple-Use Sustained-Yield Act); *id*. § 539d(a) (Tongass Timber Reform Act); *id*. § 3120(a)(3)(A) (Alaska National Interest Lands Conservation Act); *see also Natural Res. Def. Council*, 421 F.3d at 808-09 (explaining balancing of timber and other goals in the Tongass).
[98] *See* (Board of Forestry Excerpts (Aug. 28, 2019).

resulting from tariffs soften export demand and reduce the competitiveness of Alaska in the world marketplace?[99]

The DEIS, however, fails to consider alternatives in which the agency's Export Policy is not adopted and/or applied to the Central Tongass Project.[100] Variations on the Limited Export Policy are not even included among the "Alternatives Considered But Eliminated From Detailed Review."[101] The DEIS fails to explain why domestic alternatives with smaller volumes could not fulfill the Project's purpose and need. The DEIS offers no explanation why the agency did not consider these variations and the resulting differential environmental impacts. By excluding variations on the "Current Region 10 Export Policy," the DEIS excludes reasonable alternatives that fall within the project's "purpose and need," in violation of NEPA.[102]

The Forest Service's decision to apply any export policy, including the "Current Region 10 Export Policy," to the Central Tongass Project requires analysis of the resulting impacts in a new DEIS. The agency must provide a "full and fair discussion of significant environmental impacts" of the decision to allow exports, including but not limited to resultant increases in logging and the impacts on ecosystems that will follow from the resultant logging.[103] At one end, with no export, there would be less logging but more jobs per unit of timber logged and greater protection of wildlife, biological diversity, carbon stores, carbon sequestration, subsistence uses, and the recreation, tourism, and fishing sectors of the economy. At the other end is the "Current Region 10 Export Policy," which emphasizes timber production with fewer jobs and higher adverse impacts and costs on all other values. The agency must analyze these impacts in a supplemental DEIS; the failure to do so will violate NEPA. It will also violate NFMA and the other statutes under which the Forest Service operates when it approves a timber sale given the inherent tradeoffs and balancing the agency must make in deciding how to pursue competing objectives.

For the reasons stated above, the Central Tongass Project accomplishes nothing more than miring Southeast Alaska in the destructive and controversial practices of industrial-scale old-growth logging. As the Project demonstrates with vivid clarity, the Tongass timber program is economically and environmentally unsustainable and, as a result, the Forest Service should not move ahead with the logging aspects of the Project. If the Forest Service decides to move ahead with logging, then the agency must prepare a supplemental DEIS that corrects the deficiencies described above.

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[99] *See* DEIS at 318.
[100] DEIS at 25-26.
[101] *Id.* at 26.
[102] *See City of Carmel-By-The-Sea v. U.S. Dep't of Transp.*, 123 F.3d 1142, 1155 (9th Cir. 1997) ("Project alternatives derive from an Environmental Impact Statement's 'Purpose and Need' section, which briefly defines the underlying purpose and need to which the agency is responding in proposing the alternatives . . . [and which] necessarily dictates the range of reasonable alternatives." (quotation marks omitted)); *Natural Res. Def. Council*, 421 F.3d at 814.
[103] *See Conservation Cong. v. Finley*, 774 F.3d 611, 616 (9th Cir. 2014) (quoting 40 C.F.R. § 1502.1).

VII. THE FOREST SERVICE FAILS TO DISCLOSE THE COSTS, IMPACTS, AND ALTERNATIVES TO PUBLICLY SUBSIDIZING Roads AND ACCESS MANAGEMENT.

Given the uncertainty of the "condition-based" analysis, the Forest Service's assessment, disclosure, and consideration of road costs and impacts (including construction, maintenance, and decommissioning) is incomplete and misleading. This renders the DEIS unlawful under NEPA and would render any decision arbitrary under NFMA and the other statutes governing timber sales.

The DEIS contemplates public subsidies for transportation infrastructure: "In some years, appropriated funds are available to pay for all or a portion of NFS road costs for roads used for a timber sale, as well as the long-term administration of the national forest."[104] In an attempt to counteract the troubling economic realities of the Tongass timber program, the Forest Service appears poised to take an extraordinary and costly measure: the agency might contract to perform most, if not all, of the road construction and reconstruction required for the project at public expense, reducing the costs to the logger but shifting them to the taxpayer. This decision must be analyzed and disclosed in a new DEIS and the implications of this decision explained in the agency's balancing of competing interests under NFMA and the other statutes governing timber sales.

Based on recent experience, the Forest Service's decision whether to pay for some or all of the road costs associated with Tongass timber sale projects directly affects the agency's balancing of competing interests. By way of illustration, in advance of the North Kuiu Timber Sale, advertised in 2018 at 13.5 MMBF,[105] the Forest Service spent $3.1 million to construct and recondition over 80 miles of roads on Kuiu Island.[106] This amount more than quadrupled the road costs the agency projected for the Kuiu sale in its EIS.[107] By pre-roading the sale, the agency shifted these road costs from the purchaser to the public. Moreover, the fact the North Kuiu sale had a minimum bid of less than $200,000 - or less than 7% of the cost to taxpayers of

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[104] DEIS at 64.
[105] U.S Forest Service, Bid Letter for North Kuiu #2 Sale (May 5, 2018).
[106] *See* Kuiu Rd & Bridge Replacement, AG-0120-S-14-0011, Amendment 003, Replacement Pages Section B, Kuiu Contract_Redacted at PDF 11-25 (2014) (identifying roadwork covered by the base bid and options 1-7); Amendment of Solicitation/Modification of Contract (Apr. 23, 2014), Kuiu_sf30_Mod_6_Redacted (Modification 6) (adding roadwork to one road and providing the final contract total of $3,083,813.00). These records were submitted with SEACC's Sept. 24, 2018 scoping comments for the Central Tongass Project (CTPR 832_0304).
[107] Compare U.S. Forest Service, Kuiu Timber Sale Area, Final Environmental Impact Statement at 2-15 (Tbl. 2-2, Alt 5), 3-60 (Tbs. 3-19 & 3-20, Alt 5) (July 2007) (projecting road costs of $54.09/MBF) with Amendment of Solicitation/Modification of Contract (Apr. 23, 2014), Kuiu_sf30_Mod_6_Redacted (Modification 6) (providing $3,083,813.00 road cost, which, divided by the current proposed timber sale volume of 13,643 MBF, yields a cost of $226.04/MBF). These records were submitted with SEACC's Sept. 24, 2018 scoping comments for the Central Tongass Project (CTPR 832_0304).

road construction - demonstrates the arbitrary nature of the Forest Service's balancing of competing interests.

In sum, the Forest Service's decisions in this regard have direct bearing on the agency's analysis of the costs and benefits of the Central Tongass Project, as well as the resulting impacts and alternatives. The DEIS admits that the Forest Service might force the public to pay for some or all of the road costs for the Central Tongass Project over the next 15 years.[108] Yet, inexplicably, the agency fails to examine those costs and the resulting impacts of that decision (*i.e.*, likelihood a timber sale will appraise positively) and justify the decision to use taxpayer funds to cover those costs. A supplemental DEIS should include consideration of an alternative that requires the bidder to pay all the costs associated with road construction and maintenance, and evaluate whether this will mean fewer clearcuts and less miles of roads bulldozed. Thus the information presented in the DEIS is incomplete and presents an inaccurate assessment. The agency must prepare a new DEIS that corrects these failings and examine the impacts that approach will have on the Central Tongass Project. To do otherwise, the agency will violate NEPA and reach an arbitrary conclusion under NFMA.

VIII. THE FOREST SERVICE Fails TO TAKE A HARD LOOK AT THE IMPACT OF HERBICIDES.

The DEIS fails to take a hard look at the impacts of herbicide use in the Central Tongass project. The DEIS overlooks the impact of herbicide use on non-target species. For example, the DEIS fails to give any consideration to the impacts of herbicide use on pollinators. Alaska boasts a great diversity of native bee species, yet the DEIS fails to consider the impacts of herbicide use on native bees or even mention them at all. The vast majority of native bee species are cavity or ground nesting, thus the preferred alternative could result in these species creating nests and leaving eggs to hatch in sites where herbicides have been applied. Herbicide use in these sites could lead to the failure of brooding sites for years to come. In addition, many native bees and pollinators are incredibly specialized and do not travel more than a couple hundred yards, thus the killing or even disturbance of a small patch of plants via herbicide could have significant impacts on an important population.[109] Herbicide use is a leading cause of the decline of butterflies, and other pollinator species, because of its impacts to the floral resources they rely on.[110] Many species of native bees and pollinators remain understudied and rely on federal public lands, but the use of herbicides proposed in the action alternatives could have significant harmful impacts on these populations.

In addition to native pollinators, the DEIS fails to consider impacts to honeybees. Recent, peer reviewed and scientific studies have shown that herbicides interfere with the microbiomes, and

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[108] DEIS at 64 ("In some years, appropriated funds are available to pay for all or a portion of NFS road costs for roads used for a timber sale, as well, as the long-term administration of the national forest.").

[109] Endangered mutualisms: The Conservation of Plant-Pollinator Interactions, Carol A. Kearns, David W. Inouye, and Nickolas M. Waser, Annual Review of Ecology and Systematics 1998 29:1, 83-112.

[110] *See e.g.,* Petition to List Monarch Butterfly, Center for Biological Diversity et al, 2014. https://www.biologicaldiversity.org/species/invertebrates/pdfs/Monarch_ESA_Petition.pdf.

subsequently the survival of honeybees.[111] This new and emerging body of research indicates that herbicide use, once considered relatively benign for honey bees outside of the impacts to floral resources, has a more significant impact than previously considered.

The DEIS also fails to adequately consider the impacts of proposed herbicide use on avian species, especially those cavity nesting species that may use sites where herbicides would be used under the action alternatives.

The DEIS fails to take a hard look at the impacts of herbicide use on ESA listed plants and animals, or indeed the impacts on any wildlife species. The DEIS summarily dismisses such potential impacts. "All treatment methods have the potential to disturb, temporarily displace, or directly harm various wildlife species. However, impacts from treatments tend to be short term . . . ."[112] General statements about effects and risks without providing definitive information does not constitute a hard look as required by NEPA.

Regarding the specific chemicals at use, it must be noted that the EPA has never completed ESA consultation on any of these pesticides and thus their impacts to non-target listed species cannot be described with any certainty. The EPA's systematic failure to engage in ESA consultation on pesticides is the subject matter of numerous lawsuits by the Center for Biological Diversity and others.

The DEIS fails to take a hard look at the impacts of herbicide use within municipal watersheds or near areas of human habitation. Herbicide treatments may occur within watersheds used as drinking water supplies.[113] The DEIS contains no description of the current levels of pollution within these watersheds, and states only that "Appendix A describes design features to protect drinking water consistent with 2016 Forest Plan direction."[114] Those design features (buffers for application of herbicides) do not guarantee a lack of impacts, and in any event the DEIS contains no information evaluating the effectiveness of such buffers.

On the subject of human health, the DEIS fails to take a hard look at the impacts of herbicide use on the health of the workers applying the pesticides. What kind of worker protection and training would be required for pesticide handlers? Would pesticide handlers be required to obtain training on safe pesticide application or obtain certified pesticide handler training? How will emergencies such as accidental pesticide exposure by individuals inexperienced in pesticide application if such emergencies occur in remote locations? What about impacts to those who harvest wild food and other plant materials? Further, despite the fact that Alaskans and tourists harvest berries,

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[111] The Herbicide Glyphosate Negatively Affects Midgut Bacterial Communities and Survival of Honey Bee during Larvae Reared in Vitro**,** Pingli Dai, Zhenxiong Yan, Shilong Ma, Yang Yang, Qiang Wang, Chunsheng Hou, Yanyan Wu, Yongjun Liu, and Qingyun Diao. *Journal of Agricultural and Food Chemistry* **2018** *66* (29), 7786-7793 DOI: 10.1021/acs.jafc.8b02212.
[112] DEIS at 116.
[113] DEIS at 164 ("Multiple surface water rights near Wrangell and Petersburg, as well as potential potable water supply users on private property are in watersheds with proposed harvest units in both Wrangell and Petersburg"); *see also* DEIS Appendix A at A-40.
[114] *Id*. *See also* DEIS Appendix A at A-40 (resource-specific design features for invasive treatments within Public Water Sources).

mushrooms, and other flora for subsistence or recreation, the DEIS contains little analysis of pesticide impacts via such pathways.

We encourage the Forest Service to consider and adopt an alternative that utilizes only manual and mechanical treatments to eradicate and control existing and or new infestations of invasives. Herbicides have substantial adverse effects. They can also be ineffective. For example, herbicides often do not kill whole plants but do cause leaves to wither, giving the appearance of an invasive species treatment being effective for a couple weeks, until the crew has left the area, the plant recovers and starts putting on leaves once more.

The list of resource-specific design features for invasive treatments on karst requires: "Determin[ination of] karst vulnerability" but only "areas of high vulnerability karst, catchment areas contributing to them, and required protections."[115] This feature is inconsistent with direction in the 2016 TLMP because it applies only to "areas of high vulnerability karst [and] catchment areas contributing to them." The Forest Plan, however, requires a karst vulnerability assessment before any surface management practices, including application of herbicides, occurs on moderate and high vulnerability karst terrain.[116] Instructions included with Objection Response POWLLA # 19-1-00-0010 require that: "A karst vulnerability assessment will be completed prior to any surface management practice, including application of herbicide in karst terrain." At a minimum, the Central Tongass Project should contain the same direction to ensure consistency with the 2016 TLMP, as required by the NFMA.

IX. THE CENTRAL TONGASS DEIS FAILS TO TAKE A HARD LOOK AT CUMULATIVE IMPACTS.

NEPA's implementing regulations require that EISs must consider the cumulative impacts of the action under consideration, and defines cumulative impacts as "the incremental impact[s] of the action when added to other past, present, and reasonably foreseeable future actions."[117] Forest Service regulations define a reasonably foreseeable future action as an "[i]dentified proposal[],"[118] which exists where the agency "has a goal and is actively preparing to make a decision on one or more alternative means of accomplishing that goal and the effects can be meaningfully evaluated."[119]

Federal case law and agency guidance make clear that an agency is required to consider a proposal's cumulative effect, even if an agency has not approved that action, because agencies must review impacts when they are "reasonably foreseeable," not when they are "absolutely certain." "[P]rojects need not be finalized before they are reasonably foreseeable."[120] "NEPA requires that an EIS engage in reasonable forecasting. Because speculation is . . . implicit in NEPA, [ ] we must reject any attempt by agencies to shirk their responsibilities under NEPA by

[115] DEIS Appendix A at A-42.
[116] 2016 TLMP Amendment, Appendix H, Sec. III.4.
[117] 40 C.F.R. § 1508.7.
[118] 36 C.F.R. § 220.3.
[119] 36 C.F.R. § 220.4(a)(1).
[120] *N. Plains Res. Council, Inc. v. Surface Transp. Bd.*, 668 F.3d 1067, 1078-79 (9th Cir. 2011).

labeling any and all discussion of future environmental effects as crystal ball inquiry."[121] As the Environmental Protection Agency also has concluded, "reasonably foreseeable future actions need to be considered even if they are not specific proposals."[122] "It is not appropriate to defer consideration of cumulative impacts to a future date when meaningful consideration can be given now."[123]

For the Central Tongass EIS, the Forest Service has failed to disclose the cumulative effects of this proposed project along with at least four other proposals: one already approved, one categorically excluded from NEPA review, and two projects for which scoping is completed and a DEIS expected.

A. The Prince of Wales Logging Project.

The Forest Service fails to address or acknowledge the potential cumulative impacts from an already-approved project, the Prince of Wales Landscape Level Analysis Project (Prince of Wales Project). That project, for which the Forest Service issued its record of decision in March 2019, authorizes 15 years of logging on Prince of Wales Island and smaller surrounding islands in the Tongass National Forest. It would cut up to 42,635 acres of mostly old-growth forest and build up to 164 miles of new roads.[124] While the Forest Service drew the "project boundaries" of the Prince of Wales Project and the Central Tongass Project so that they do not overlap, the boundaries are separated by a few miles of water or less in many places.[125] Neither project's environmental analysis mentions the other project.

The two projects will have numerous overlapping and cumulative impacts because resources impacted by each project extend beyond the project boundaries of either project. For example, both projects will have overlapping and cumulative effects on the local economy, as the lumber from both projects is likely to feed the same mill (Viking Lumber), which the Forest Service describes as "the last operating medium-sized sawmill in Southeast Alaska."[126] As discussed below, the two projects together appear to exceed the old-growth target set in the Forest Plan for transitioning away from old-growth logging.

The Tongass Plan Amendment of 2016 proposed accelerating the transition of the Forest's timber program from primarily old-growth to almost exclusively young growth within 15 years,

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[121] *Selkirk Conservation Alliance v. Forsgren*, 336 F.3d 944, 962 (9th Cir. 2003) (internal quotation marks and citation omitted).
[122] EPA, *Consideration of Cumulative Impact Analysis in EPA Review of NEPA Documents*, Office of Federal Activities, 12-13 (May 1999), available at https://www.epa.gov/sites/production/files/2014-08/documents/cumulative.pdf (last viewed Sep. 16, 2019).
[123] *Envtl. Prot. Info. Ctr. v. U.S. Forest Serv.*, 451 F.3d 1005, 1014 (9th Cir. 2006) (internal quotation marks and citation omitted).
[124] *See* Prince of Wales Project, Record of Decision at 1.
[125] Compare Forest Service, Prince of Wales Project Final EIS at 9 (Figure 2) with Central Tongass Project DEIS at 3 (Figure 1).
[126] DEIS at 309.

or by the end of 2031.[127] This direction implemented the consensus recommendations from the Tongass Advisory Committee, "a formally established Federal Advisory Committee that included representatives from Federally Recognized Tribes, Alaska Native organizations, Alaska Native corporations, national and regional environmental and conservation organizations, timber industry operators, Federal, State, and local governments, permittees, other commercial operators, and the general public."[128] The TAC recommended that:

> In regards to the harvest of old growth trees, the principle employed is to replace old growth harvest with young growth harvest within 10-15 years, except for small operators dependent on low-volume, niche markets. The 2016 Plan Amendment should provide the flexibility for USFS staff, partners, and collaborators to succeed in transitioning the Southeast Alaska timber industry from predominantly old growth to young growth.[129]

The Forest Plan ROD adopted this direction.

> [U]nder Alternative 5 [the selected alternative] the Agency expects to sell an average of about 12 MMBF of young growth and 34 MMBF of old growth per year during the first 10 years. From Year 11 through Year 15, it expects to sell an average of 28 MMBF of young growth and about 18 MMBF of old growth per year. Alternative 5 is expected to reach a full transition of 41 MMBF of young growth about Year 16. Young-growth sales are expected to continue to increase at a rapid rate after Year 16 and are expected to reach an upper limit of 98 MMBF about Year 18. Old-growth timber will continue to be offered at an average rate of 5 MMBF per year to support small operators and specialty products such as wood for musical instruments.[130]

Year 1 of the Forest Plan was 2017.

The Prince of Wales project itself could supply a significant amount of the old-growth timber target under the Amended Plan. The Prince of Wales Record of Decision indicates that the project will offer "[u]p to an average of 25 million board feet . . . of old-growth timber annually from suitable timber lands . . . during the first 5 years of implementation," or roughly from 2020-2024.[131] During the next 5-year period, or from 2025-2029, the Forest would offer "up to an average of 15 MMBF of old-growth timber annually.[132] From 2030-2031 "up to 10 MMBF of

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[127] Forest Service, 2016 Tongass National Forest Plan Record of Decision (ROD)) at 5 ("Changes to the Plan are focused on accelerating the transition from a primarily old growth to a primarily young-growth timber program").
[128] 2016 Tongass Amendment ROD at 6.
[129] Tongass Advisory Committee, Final Recommendations (Dec. 2015) at 2, attached as Appendix B to the 2016 Tongass Plan Amendment; *see also id*. at 7 ("the overall transition period is defined by the TAC [Tongass Advisory Committee] as a period *not to exceed 15 years* from the date of this Amendment's ROD," December 9, 2016) (emphasis added).
[130] Forest Service, Tongass National Forest Plan Record of Decision (2016) at 7.
[131] Prince of Wales Project, Record of Decision at 2.
[132] *Id*.

old-growth timber may be offered," and during the final 3 years, 2032-2034, "up to 5 MMBF of old-growth timber" could be sold."[133]

The Central Tongass DEIS proposes the following schedule for logging the 150 million board feet of old-growth the project proposes to be logged:

> An average of approximately 20 MMBF of harvest from suitable timber lands is proposed annually during the first 5 years of implementation [or roughly 2020-2024, assuming the ROD is issued next year]. During the next 5-year period [or roughly from 2025-2029], the average annual old-growth harvest is proposed to drop to 7 MMBF and drop again for the last 5-year period [or roughly from 2030-2034] (4 MMBF of annual old-growth harvest).[134]

If combined, the old-growth logging schedules for both projects will exceed the old-growth timber targets for 9 of the next 15 years. *See* Table 1 below.

Table 1. Old-Growth Logging Offered Annually (in MMBF)

Year	Prince of Wales[1]	Central Tongass[2]	Prince of Wales + Central Tongass[3]	Tongass Forest Plan (2016) Target[4]
2020-2024	25	20	***45***	34
2025-2026	15	7	22	34
2027-2029	15	7	***22***	18
2030-2031	10	4	14	18
2032-2034	5	4	***9***	5

[1] Prince of Wales Record of Decision at 2.
[2] Central Tongass DEIS at 23.
[3] This column sums the previous two columns. Years where the two projects combine exceed Plan direction are bolded and italicized. [4] Tongass Forest Plan Record of Decision (2016) at 7.

[133] *Id.*
[134] DEIS at 23.

In short, these two projects alone could exceed the Tongass Forest Plan's target for average level of old-growth cut for most of the next 15 years. A cumulative impact analysis could inform the public and decision makers as to the likelihood that the agency can meet the transition goals set in the 2016 Forest Plan.

In addition, clearcutting and road-building on the massive scale as contemplated in both projects are likely to impact cumulatively endemic species, including the Alexander Archipelago wolf and the Sitka black-tailed deer, that inhabit both project areas.[135] This cumulative damage to wolf and its habitat in particular may be significant.

Both projects will also degrade habitat for the Queen Charlotte goshawk.[136] The goshawk's range includes both project areas, and goshawk are likely to travel between the two areas. With downward population trends likely in both project areas, the potential for impacts across the entirety of this specie's range increases, a cumulative impact that neither EIS analyzes. Similarly, the American marten occurs within both project areas, and each project will degrade habitat for that mammal, raising the specter of cumulative impacts.[137]

B. South Revillagigedo Logging Project.

The Central Tongass DEIS also fails to consider, or even mention, the potential impacts of the South Revillagigedo Integrated Resource Project (South Revilla Project). This project is reasonably foreseeable because the Forest Service has issued a detailed proposal, and is currently preparing a DEIS which the agency estimates could be published this month, or a few months from now.[138] This project "would authorize the harvest up to 46 million board feet of timber from up to 5,500 acres of old-growth forested land and up to 1,000 acres of young-growth in the modified landscape and timber production land use designations (LUDs) using one or more

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[135] DEIS at 104 (Table 27) (predicting "moderate impacts" to the wolf and deer from the Central Tongass Project); Prince of Wales Project Final EIS at 235 ("89 percent of the project area WAAs [wildlife analysis areas] have some level of wolf mortality concern"); *id*. at 99 (disclosing a "significant possibility of a significant restriction" to subsistence uses of deer); Prince of Wales Project Record of Decision at 15 (predicting "Moderate to Major" to wolf and deer in light of this substantial pre-existing loss of habitat).

[136] DEIS at 133 (under proposed action, "there will be adverse impacts to individuals and or habitat"); Prince of Wales Project Record of Decision at 13 ("the overall loss of HPOG [high volume productive old-growth] habitat on all lands could contribute to downward population trends for this species in the project area.").

[137] *See* DEIS at 340 ("Timber harvest with removal of [productive old-growth], and the associated fragmentation and road building which increases subsistence harvester access, could affect the local abundance and distribution of … American marten"); *id*. at 104, Table 27 (concluding project would have "moderate" impacts to American marten); Prince of Wales Project Record of Decision at 14 (concluding project would have "moderate" impacts on American marten and that "The overall loss of average snow marten habitat on all lands could contribute to downward population trends for this species in the project area.").

[138] 84 Fed. Reg. 31,288 (July 1, 2019) ("The DEIS is expected to be published in September 2019"); South Revilla Scoping Information document at 1 (DEIS expected in January 2020).

timber sales, with activities occurring over the course of 15 years" in the Ketchikan Misty Fjords Ranger District.[139]

Because of its proximity to Ketchikan, Saxman, and Metlakatla, the South Revilla project area is an important deer hunting area for these communities. Given the existing and reasonably foreseeable cumulative impacts from logging and road building on old-growth across all land ownerships within and adjacent to the South Revilla project area, we have serious concerns about the impact from additional old-growth logging within this project area on the distribution and abundance of deer for subsistence and sport use. The most recent NEPA analysis for lands within the project area between George and Carroll Inlets concluded, "[c]urrent deer populations on Revillagigedo Island are thought to be at very low levels."[140] The anticipated habitat reductions will cause substantial adverse effects to subsistence use of deer for these communities and result in increased competition for local hunters.

As with the Prince of Wales Project, South Revilla is not directly adjacent to the Central Tongass Project Area though it is only a 20 or so miles south of it. Forty-six million board feet of timber, largely from old growth logging, will further add to the likely exceedance of Forest Plan direction, and further undermine the transition to young growth logging directed by the Forest Plan. In addition, old-growth logging may further degrade habitat for the Alexander Archipelago wolf, Queen Charlotte goshawk, American marten and other old-growth-dependent wildlife. The triple assault from the Prince of Wales, South Revilla, and Central Tongass projects may have cumulative impacts on these (and other) species.

C. Repeal Of The Roadless Area Conservation Rule In Alaska.

The Central Tongass DEIS fails to acknowledge or consider the potential impacts of another reasonably foreseeable Forest Service proposal: the proposed repeal of the National Roadless Rule on the Tongass National Forest. The Forest Service issued a scoping notice to eliminate the Roadless Rule on the Tongass National Forest within the State of Alaska over a year ago, and expects to issue a DEIS imminently.[141] The draft rule only awaits clearance from the Office of Management and Budget, and the office of the Secretary of the Department of Agriculture.[142] A

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[139] Forest Service, Scoping Information, South Revillagigedo Integrated Resource Project (July 2019) at 1, available at https://www.fs.usda.gov/nfs/11558/www/nepa/108739_FSPLT3_4659829.pdf (last viewed Sep. 16, 2019); *see also* Forest Service, Revised Notice of Intent to prepare an Environmental Impact Statement, 84 Fed. Reg. 31,288, 31,289 (July 1, 2019) (scoping notice, similarly characterizing project).

[140] *See* Saddle Lakes FEIS at 3-175 (2015).

[141] *See* 83 Fed. Reg. 44252 (Aug. 30, 2018) (notice of intent to prepare an EIS to address the management of inventoried roadless areas on the Tongass); *id*. at 44,253 ("The DEIS and proposed rule are estimated to be released in early summer 2019. The Final EIS is estimated to be released in spring 2020, with a final rule expected in June 2020.").

[142] *See* website of the Office of Information and Regulatory Affairs (stating that the proposed Roadless Rule repeal is "pending review" before OMB), available at https://www.reginfo.gov/public/jsp/EO/eoDashboard.myjsp?agency_cd=0500&agency_nm=USDA&stage_cd=3&from_page=index.jsp&sub_index=0 (last viewed Sep. 16, 2019).

DEIS on that proposed rule is thus likely almost complete, rendering its impacts foreseeable in the Central Tongass EIS.

Press reports indicate that President Trump has ordered the Forest Service to adopt the most destructive alternative: one that exempts all inventoried roadless areas of the Tongass from the National Roadless Rule, eliminating the Rule's protection from more than nine million acres of roadless forest, and also converting about 165,000 old-growth acres and 20,000 young-growth acres to suitable timber lands.[143] "The Central Tongass Project area includes 43 roadless areas," and each of these areas would no longer have regulatory protection from road construction for logging or for a variety of other activities.[144] Given additional logging and road construction are thus reasonably foreseeable within some or all of these 43 areas within the Central Tongass Project boundary, the impacts of these two proposals must be reviewed together, and must be reviewed before *either* of the projects is approved.

D. Proposed Plan Amendment For Moderate Vulnerability Karst.

In evaluating the effects of proposed management activities on karst resources, the agency explains that according to GIS data, over 25,000 acres of karst terrain exist on Tongass lands within the project area, but the agency has not yet assessed their vulnerability.[145] The agency proposes logging between 2,747 to 2,898 acres of young growth and assumes, based on other projects across the Tongass, about "73 percent of these lands will be found to be of moderate vulnerability."[146] When addressing cumulative effects, however, the agency explains that:

> Until the exact extent and location of any proposed action is determined, a determination of specific effects cannot be made. Assuming 2016 Forest Plan karst and cave management direction and Appendix A are fully implemented there should be no detrimental effects to those resources.[147]

This statement is incorrect based on the agency's current proposal to amend the 2016 Tongass Plan by removing the existing forest plan limits (S-YG-KC-02) for how much young growth is operable for logging on moderate vulnerability karst lands. According to the analysis of young growth suitability, removal of this standard increases by seventeen percent the number of moderate vulnerability karst lands 100% suitable for clearcut logging in surveyed young growth stands on Prince of Wales Island.[148] Thus, between around 2,005 and 2,100 acres of moderate vulnerability could become 100 % suitable within the Central Tongass project record. Clearly,

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[143] *See* J. Eilperin & J. Dasey, *Trump pushes to allow new logging in Alaska's Tongass National Forest*, Washington Post (Aug. 27, 2019) and available at https://www.washingtonpost.com/climate-environment/trump-pushes-to-allow-new-logging-in-alaskas-tongass-national-forest/2019/08/27/b4ca78d6-c832-11e9-be05-f76ac4ec618c_story.html (last viewed Sep. 16, 2019).
[144] DEIS at 44.
[145] DEIS at 257.
[146] *Id.* at 259.
[147] *Id.* at 262.
[148] *See* Tongass Young Growth Suitability Synopsis at 3 (R.Sheets, 2018) (AR 832_0631).

this will have some detrimental effects on karst resources that the Forest Service failed to consider.

E. Other Projects.

Even where the Forest Service does purport to address cumulative impacts, however, the agency fails to take the hard look NEPA requires. The DEIS identifies numerous past, present, and foreseeable future projects in Appendix C, but that appendix simply lists the location, a timeframe, and a very general description of each project. It does not disclose any useful information about the impacts those projects may have when considered cumulatively with the Central Tongass Project, as NEPA requires. The DEIS itself contains only the most general discussion of cumulative impacts aside from the list at Appendix C. Federal courts conclude that the Forest Service must not only give a "sufficiently detailed catalogue of past, present, and future projects," it must also "provide an adequate analysis about how these projects . . . are thought to have impacted the environment."[149] The Forest Service failed to provide such "adequate analysis."

F. Clarification Needed About Ongoing Alaska Mental Health Trust Exchange.

In describing land status within the project area, the DEIS states that there are about 4,942 acres of lands within the Petersburg and Wrangell Ranger Districts currently owned by the Alaska Mental Health Trust that are to be exchanged to the Forest Service.[150] This acreage appears to exclude the currently owned Trust parcel at No Name Bay, on Kuiu Island within the Petersburg Ranger District, which comprises approximately 3,374 acres. Any subsequently prepared NEPA document must explain this discrepancy.

X. THE FOREST SERVICE'S EVALUATION OF ROADS AND MOTOR VEHICLE TRAILS VIOLATES THE TRAVEL MANAGEMENT RULE AND NEPA.

The Central Tongass Project proposes to undertake two actions related to transportation and travel management within the project area. First, Alternative 2 would approve the construction of 25 miles of new roads that would be added to the National Forest road system, and construct 93 miles of "temporary" road.[151]

Second, Alternative 2 proposes to "[d]esignate 128 miles of existing NFS road as Motorized Trails open to OHV < 50 inches wide (such as ATVs or motorcycles). These roads would follow criteria outlined in 36 CFR 212.55, and be displayed on the district's annual Motor Use Vehicle Map. The roads are currently closed, or are already planned for future closure."[152]

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[149] *Te-Moak Tribe v. U.S. Dep't of the Interior*, 608 F.3d 592, 603 (9th Cir. 2010) (internal quotation marks omitted).
[150] DEIS at 53.
[151] DEIS at 29 (Table 4).
[152] DEIS at 21.

To date, the Forest Service has failed to comply with federal law and regulations concerning these proposed actions.

A. The Travel Management Rule Governs The Forest Service's Consideration Of New Roads And Trails.

1. The Forest Service Must Identify the "Minimum Road System."

The Travel Management Rule (TMR) sets forth rules for travel and transportation systems in national forests.[153] The TMR was promulgated "to improve implementation of the [relevant] executive orders and establish a national system of roads, trails, and areas with restricted ORV use."[154] Under the Rule, the Forest Service must "identify the minimum road system needed for safe and efficient travel and for administration, utilization, and protection of National Forest System lands."[155]

> The minimum system is the road system determined to be needed to meet resource and other management objectives adopted in the relevant land and resource management plan . . . , to meet applicable statutory and regulatory requirements, to reflect long-term funding expectations, to ensure that the identified system minimizes adverse environmental impacts associated with road construction, reconstruction, decommissioning, and maintenance.[156]

The Forest Service must also designate roads for decommissioning.[157] Designation of the minimum road system and road decommissioning must be accomplished by completing a "science-based roads analysis at the appropriate scale," and incorporating, to the degree practicable, the interests of affected citizens and state, local, and tribal governments.[158] This process results in a "travel analysis report" for a given area, which sets forth a recommended minimum road system for a given area. Generally speaking, the analysis and recommendation provided in the travel analysis report will inform the agency's analysis during the subsequent NEPA process for a particular site-specific project.

2. The Forest Service Must Demonstrate How It Achieved the Objective of Minimizing Environmental Damage.

Executive Order 11644 directs "agencies to promulgate regulations that require that all 'areas and trails' allowing off-road vehicles ('ORVs') on public lands be located in areas that"

> (1) ... minimize damage to soil, watershed, vegetation, or other resources of the public lands[;]

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[153] Administration of the Forest Development Transportation System, 66 Fed. Reg. 3206 (Jan 12, 2001) (Subpart A codified at 36 C.F.R. §§ 212.1 to 212.21).
[154] *WildEarth Guardians v. Montana Snowmobile Ass'n*, 790 F.3d 920, 929 (9th Cir. 2015).
[155] 36 C.F.R. § 212.5(b)(1).
[156] *Id.*
[157] *Id.* § 212.5(b)(2).
[158] *Id.* § 212.5(b)(1).

> (2) ... minimize harassment of wildlife or significant disruption of wildlife habitats[; and,]
>
> (3) ... minimize conflicts between off-road vehicle use and other existing or proposed recreational uses of the same or neighboring public lands, and to ensure the compatibility of such uses with existing conditions in populated areas, taking into account noise and other factors.[159]

The Travel Management Rule requires National Forests to specify routes, vehicle types, and seasons of motorized travel on roads, trails, and other areas.[160] It prohibits motor vehicle use off designated roads and trails and outside designated areas.[161]

In designating roads, trails, and areas, the Forest Service must

> consider effects on National Forest System natural and cultural resources, public safety, provision of recreational opportunities, access needs, conflicts among uses of National Forest System lands, the need for maintenance and administration of roads, trails, and areas that would arise if the uses under consideration are designated; and the availability of resources for that maintenance and administration.[162]

The Forest Service must also

> consider effects on the following, with the objective of minimizing:
>
> (1) Damage to soil, watershed, vegetation, and other forest resources;
>
> (2) Harassment of wildlife and significant disruption of wildlife habitats;
>
> (3) Conflicts between motor vehicle use and existing or proposed recreational uses of National Forest System lands or neighboring Federal lands; and
>
> (4) Conflicts among different classes of motor vehicle uses of National Forest System lands or neighboring Federal lands.
>
> In addition, the responsible official shall consider:
>
> (5) Compatibility of motor vehicle use with existing conditions in populated areas, taking into account sound, emissions, and other factors.[163]

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[159] *WildEarth Guardians v. Mont. Snowmobile Ass'n*, 790 F.3d 920, 929 (9th Cir. 2015) (footnote omitted) (quoting Exec. Order 11644 §§ 3(1)-(3) ("Use of Off-Road Vehicles on the Public Lands") (Feb. 8, 1972)).
[160] 36 C.F.R. §§ 212.50(a), 212.51(a).
[161] *Id.* §§ 212.50(a), 261.13.
[162] *Id.* § 212.55(a).
[163] *Id.* § 212.55(b).

These are known as the "minimization criteria."[164] "[T]he TMR requires the Forest Service to apply the minimization criteria to each area designated for [OHV use].[165] "[T]he Forest Service must provide a more granular minimization analysis to fulfill the objectives of . . . which the TMR was designed to implement."[166] "What is required is that the Forest Service document how it evaluated and applied the" TMR analysis "on an area-by-area basis with the objective of minimizing impacts as specified in the TMR."[167]

"[M]ere consideration of the TMR's minimization criteria is not sufficient to comply with the regulation."[168] "Rather, the Forest Service must apply the data it has compiled to show how it designed the areas open to [OHV] use with the objective of minimizing damage to" various forest resources.[169] "The TMR is concerned with the effects of each *particularized area and trail designation*."[170] Forest Service NEPA documents evaluating ORV routes will be set aside where the agency "fails to demonstrate, at the 'granular' area-and trail-level, how routes were designated or located, how the minimization criteria were evaluated and implemented, how data was applied, [and] how impacts were minimized."[171]

B. The Forest Service Fails To Identify The Minimum Road System.

The DEIS and appendices fail to demonstrate that the Forest Service has ensured that the 25 miles of new road are necessary to achieve the "minimum road system," as required by 36 C.F.R. § 212.5. In fact, none of the documents even contains the phrase "minimum road system." The DEIS contains boilerplate language asserting that the agency will mitigate the impacts of route construction and use, but this is not the same as ensuring that the routes comply with the TMR's "minimum road system" mandate.[172]

The only rationale provided for adding 25 miles to the road system is: "The need for road construction is mostly determined by the need to access timber units."[173] Whether all of these miles of road meet the definition of a route that fits within the "minimum road system" is questionable because the DEIS admits that: "Not all roads of the gross unit pool may be

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[164] *Mont. Snowmobile Ass'n*, 790 F.3d at 930.
[165] *Id.*
[166] *Id.* at 931.
[167] *Id.*
[168] *Id*. at 932.
[169] *Id.* (quotation omitted).
[170] *Id.* (emphasis added). *See also WildEarth Guardians v. Jeffries*, 370 F. Supp. 3d 1208, 1248-49 (D. Or. 2019) (setting aside Forest Service decision where agency merely considered the minimization criteria).
[171] *Id*., 370 F. Supp. 3d at 1250, citing *Mont. Snowmobile Ass'n*, 790 F.3d at 930-32.
[172] *See* DEIS at ii, 7 (road construction and related "activities are intended to maintain and manage a safe, cost-effective transportation system that supports management activities and provides Forest users access to subsistence, recreation and traditional use opportunities, and minimizes effects on wildlife and fish habitat, riparian habitat, and wetlands.").
[173] DEIS at 360. *See also* DEIS Appendix A at A-94 ("NFS road construction occurs when vehicular access is needed … generally for timber harvest").

constructed or needed, however."[174] If some of the roads may not be "needed," it is difficult to see how they could be part of the *minimum* road system necessary.

The DEIS further justifies changing the level of vehicle use on routes in order to "align with how roads are currently being used."[175] The fact that routes are "being used" does not mean that the routes are needed or are not having detrimental impacts, or that the current level of use is the minimum needed "to meet resource and other management objectives."[176] The DEIS does not address these critical factors as required by law.

Although Forest Service regulations require that the minimum road system "reflect long-term funding expectations,"[177] the DEIS does not address whether the Forest Service can afford the added construction and maintenance costs of roads the proposed action would add to the system. The Forest Service estimates road construction and maintenance costs, but does not explain how they fit within the agency's budget.[178] In fact, the Forest Service admits: "There is no indication that additional maintenance funds would be available" for the additional miles of road, "so the existing budget would need to accommodate additional miles."[179] In fact, the Forest Service fails to disclose that the road maintenance backlog on the Tongass is currently $68 million dollars.[180] The Forest Service fails to explain if or how the agency will do more with less. Because the Forest Service fails to describe "long-term funding expectations," except to admit that the agency is unlikely to be able to maintain new roads, the agency fails to comply with the TMR's provisions concerning roads. Any subsequently-prepared NEPA document must cure these errors.

Further, lack of road maintenance can cause significant negative impacts in the form of erosion, soil degradation, water pollution and sedimentation, the spread of noxious weeds, and decreased visitor safety, among other harms. The Forest Service fails to analyze or disclose these impacts. These types of impacts also demonstrate that the road system the Forest Service proposes here will fail to "ensure that the identified system minimizes adverse environmental impacts associated with road construction, reconstruction, decommissioning, and maintenance," as required by 36 C.F.R. § 212.5(b)(1).

The Forest Service has also failed to engage in a road-by-road analysis to determine whether each route is needed. The DEIS asserts that the "project record" contains a "[r]oute-by-route ranking by resource and methodology."[181] But that ranking document is little more than a checklist of potential impacts to various characteristics without any explanation or evaluation as to why, given the impacts marked, the Forest Service would choose to close some roads, while

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[174] DEIS at 364. *See also* DEIS Appendix B at B-1 ("It is acknowledged that not all roads of the gross unit pool will be constructed or needed.").
[175] DEIS at 364.
[176] 36 C.F.R. § 212.5(b)(1).
[177] 36 C.F.R. § 212.5(b)(1).
[178] *See* DEIS Appendix B at B-11 – B-13.
[179] DEIS Appendix B at B-12.
[180] USFS Answers to Mr. Quigley, Q1 (2019).
[181] DEIS Appendix B at B-7.

choosing to add some newly-constructed routes to the system.[182] Further, beyond the location of the island on which the route is located, the table contained in the record does not identify the location, course, or length of any route, making it impossible for the public to understand the agency's logic or to identify routes on the maps provided.[183] This violates both the TMR and NEPA's "hard look" mandate.

Finally, because the specific location and impacts of individual roads are not disclosed, it is impossible for the public (or the agency) to understand whether certain routes might be particularly damaging, and therefore whether the agency should consider a reasonable alternative of removing certain routes from the system. This failure to present potential impacts in a way that would allow for the promulgation and evaluation of reasonable alternatives also violates NEPA.[184]

C. The Forest Service Fails To Comply With The Minimization Criteria For OHV Routes.

As noted, in implementing the TMRs, federal courts require the Forest Service to do more than consider the impacts of OHV routes on specific resources and allege that those impacts have been minimized. The Forest Service must *explain* "[h]ow the routes comply with the minimization criteria, specifically as to how they are located and designated to minimize these effects."[185] Further, the agency must "demonstrate, at the 'granular' area- and trail-level, how routes were designated or located, how the minimization criteria were evaluated and implemented, how data was applied, or how impacts were minimized."[186] This the Forest Service failed to do.

The DEIS itself contains little information about the 128 miles of routes to be designated as open to OHV use. The Forest Service notes that OHV use "has grown in popularity," and identifies the number of miles of new OHV trails proposed.[187] It does not indicate, for example, how wildlife may be impacted by increased trapping pressure that will result from the significant increase in lands open and adjacent to OHV routes.

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[182] *See* Central Tongass Travel Analysis (no date), in Project Record at file 832_0954.
[183] The DEIS does provide a gross scale map depicting proposed road construction and OHV routes. DEIS Appendix B at B-15. But the relationship between that map and the route segments identified in the Travel Analysis document is nowhere explained The map itself provides no segment numbers or identification of any kind. As noted above, the scale of the makes it impossible for the public or the decision-maker to understand the routes' precise location, or the impacts to values along the course of those routes.
[184] Despite this fact, some alternatives are called to mind by the map the agency does provide. The map shows a significant concentration of new road construction on Zarembo and Kupreanof Islands, despite the existence of substantial road networks in close proximity to the proposed routes. The Forest Service should consider alternatives that reduce the road mileage on both islands.
[185] *WildEarth Guardians*, 370 F. Supp. 3d at 1249.
[186] *Id*. at 1250.
[187] DEIS at 274, 364.

The DEIS's "Travel Analysis" appendix, which the DEIS cites as the location of additional analysis, does not meet the standards for minimization as required by law. For example, the appendix indicates that the evaluation of whether routes will be open or closed may be put off until after the Forest Service issues the ROD for this project:

> Approval of OHV < 50 inches in width and showing the trail on the MVUM *would occur* on a route-by-route basis. See Implementation Guide Activity 5 for information on criteria considered before allowing OHV < 50 inches in width and designating as a Motorized Trail.[188]

To the extent that the Forest Service will undertake a route-by-route analysis after completion of the NEPA process and after the decision in the Central Tongass ROD to add these routes to the system, the agency's decision to punt the actual analysis until after the agency makes its decision violates both the TMR and NEPA.

The Travel Analysis appendix further fails to demonstrate that each of the routes proposed that will make up the 128 miles of new OHV routes will meet the minimization criteria because the Forest Service admits it does not know how the routes will be maintained in a manner that will prevent environmental degradation:

> Recreation budgets are constrained, and maintenance of currently designated motorized trails does not occur. At this time *it is hard to predict* future budgets and *how the addition of motorized trails would be maintained*. Partnering with user groups who use the trails *could be* one source for maintaining trails worth investigating by the Forest Service.[189]

The appendix also contains almost no information about individual routes (disclosing only a rough approximation of their length and containing a map displaying the routes' rough location, but without any way to cross-reference the data about length), thus it does not and cannot represent the "granular" analysis that the courts have mandated.[190]

Nor can the Forest Service rely on the "Central Tongass Travel Analysis" in the project record to meet the agency's minimization duties. That document identifies individual routes by number, and, in a table or matrix, indicates whether the route will have a low, medium or high impact to a half-dozen categories of natural resources.[191] This document lacks any information to explain why certain routes are opened while others remain closed, or how those routes minimize harm to impacted resources at the route-by-route level. This is precisely the type of analysis struck down by the federal courts in *Idaho Conservation League v. Guzman*, 766 F. Supp. 2d 1056 (D. Idaho 2011). There, the Forest Service argued that a matrix identifying certain values, and whether the

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[188] DEIS Appendix B at B-5.
[189] DEIS Appendix B at B-5 (emphasis added).
[190] DEIS Appendix B at B-7 – B-11; B-15.
[191] *See* Central Tongass Travel Analysis (no date), in Project Record at file 832_0954, at PDF pages 21-31.

routes would impact such values, was sufficient analysis to meet the minimization criteria. The court rejected this approach.

> The Route Designation Matrices are not evidence of the implementation of such criteria. Instead, they contain a large number of subject boxes with a variety of different checkmarks and other notations recorded. There is no way to know how or if the Forest Service used this information to select routes with the objective of minimizing impacts. Without some explanation for how this information was implemented, the Forest Service has failed to meet the regulatory requirements contained in the 2005 Travel Management Rule.[192]

The court held that neither the NEPA analysis nor "conclusory statements in the record" were enough to "connect the dots" from the matrix to the Forest Service's decision.[193] The same is true here.

The Forest Service may not allege that design features or mitigation measures discharge the agencies' duties under the TMR. As the *WildEarth Guardians* court ruled:

> Defendants attempt to rely on project design features of the Project, as well as the SFEIS environmental analysis, to show compliance with the TMR. Defendants argue that minimization of effects occur in the analysis of the environmental impacts of the Project. However, this is not the same as an analysis and application of how the Forest Service sought to minimize such impacts with regard to the designation of routes. Education, enforcement, increased compliance, maintenance, and monitoring may all serve to reduce impacts, but this does not meet the TMR's requirement to show application of the criteria to minimize impacts when locating routes.[194]

In sum, the Forest Service's "analysis" of the OHV routes it intends to open fails to comply with the TMR's minimization requirements. Further, because the agency failed to disclose the impacts of opening each route, the DEIS fails to take the hard look NEPA requires.

As with its analysis of new National Forest System roads, the DEIS's failure to disclose site-specific impacts makes it difficult for the decision-maker or the public to propose reasonable alternatives. However, based on what little information the Forest Service does provide, the agency could have considered an alternative that would open only that portion of the 128 miles of OHV routes for which the agency concluded there would be "low" risk of impacts to all of the following values: fisheries, cultural resources, soils, watershed resources, invasive species, and wildlife habitat. Further, the Forest Service could have considered an alternative that identified certain areas (such as northern Kuiu Island) where new OHV routes would not be approved because road densities are already high and so additional OHV routes would further degrade

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[192] *Idaho Conservation League*, 766 F. Supp. 2d at 1072.
[193] *Id*.
[194] *WildEarth Guardians*, 370 F. Supp. 3d at 1250.

habitat. We urge the Forest Service to consider such alternatives in any subsequently prepared NEPA document. Failure to analyze such reasonable alternatives would violate NEPA.

XI. THE DEIS FAILS TO TAKE A HARD LOOK AT THE PROJECT'S CLIMATE IMPACTS.

The climate crisis is the preeminent environmental issue of our time, threatening to drastically modify ecosystems, alter coastlines, worsen extreme weather events, degrade public health, and cause massive human displacement. Its impacts are already being felt in the United States, and particularly and increasingly in Alaska.

Proposals such as the Central Tongass Project are likely to have significant climate pollution impacts because the Tongass National Forest is one of the planet's critical carbon sinks. As the Forest Service has recognized:

> The Tongass National Forest stores more forest carbon than any other national forest in the United States . . . . As such, a critical ecosystem service sustained by this forest is carbon sequestration (i.e., the removal of carbon dioxide from the atmosphere and keeping that carbon inactive by storing it in live or dead biomass as well as organic soil matter). This makes the Tongass National Forest a critical component in the global carbon cycle.[195]

The Forest Service has stated that "the carbon stored in the Tongass National Forest makes up about 8 percent of the carbon currently stored in the forests of the United States."[196] Other Forest Service experts have concluded that prior studies have underestimated the Tongass's ability to sequester carbon in soils; as a result they estimate that the Tongass may store up to 12 percent of the carbon of all U.S. forests.[197] Whatever the number, the Tongass "plays an important role in [the] amount of carbon that is stored globally as well as the global climatic condition … *land management and other actions taken on the Tongass National Forest can affect climate change at a local, regional, and global scale*."[198] The Tongass's moist, old forests, and the soil they protect, are particularly efficient at sequestering carbon.[199]

Logging old-growth forests in particular worsens climate change by releasing significant amounts of carbon and by preventing such forests from continuing to sequester carbon. "[M]ature forests on the Tongass National Forest likely store considerably more carbon compared to younger forests in this area (within the individual trees themselves as well as within the organic soil layer found in mature forests)."[200] This is so because when a forest is cut down,

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[195] Forest Service, Tongass Land and Resource Management Plan, Final EIS (2016) at 3-13.
[196] *Id.* at 3-15. *See also* D. DellaSala, *The Tongass Rainforest as Alaska's First Line of Climate Change Defense and Importance to the Paris Climate Change Agreements* (2016).
[197] M.C. Martin, *From rock to forest: Southeast's carbon sink*, Juneau Empire (Feb. 19, 2016) (paraphrasing Forest Service scientist.
[198] Forest Service, Tongass Land and Resource Management Plan, Final EIS (2016) at 3-19 (emphasis added).
[199] *Id*. at 3-14.
[200] *Id*. at 3-14.

the vast majority of the stored carbon in the forest is released over time as CO2, thereby converting forests from a sink to a "source" or "emitter."[201] According to a recent IPCC report, deforestation causes climate pollution, and avoiding deforestation will reduce climate pollution.[202]

This science makes clear that the proposed Central Tongass Project will worsen climate emissions. It will do so by cutting down and eliminating 9,500 acres of old-growth forest, destroying the ability of those stands and that land to sequester carbon. Further the act of chainsawing forests, building roads and other facilities, and moving wood to mills or overseas markets will result in fossil fuel emissions, adding to climate pollution. The project also proposes to increase opportunities for off-highway vehicle use on the Forest, which will lead to more fossil fuel combustion.

The DEIS acknowledges the Tongass forest's role in capturing carbon, and thus mitigating climate pollution. "Forest ecosystems, such as those managed on the Tongass National Forest, represent a large terrestrial sink for carbon, such that the United Nations Framework Convention on Climate Change has recognized forest management as an effective strategy for off-setting GHG [greenhouse gas] emissions (Wilson et al. 2013). A widely recognized ecosystem service provided by the Tongass is carbon flux regulation."[203] Despite the critical importance of intact Tongass old-growth to maintaining carbon stores, and the fact that the clearcuts proposed for this project will degrade those stores, the DEIS relegates climate change to: "Resources Not Discussed in Detail. Resources likely to remain unaffected by this project, or those that do not have measurable effects."[204] Both of these contentions are incorrect. Climate pollution will be worsened because of this project, and the effects are capable of estimation.

The Forest Service further explains that it declines to undertake a more detailed analysis of climate analysis because the agency consider it too hard. "How carbon storage, carbon sequestration, timber harvest, vegetative regrowth and carbon emissions interact over time *is very complex*, making it unrealistic to define a temporal scope of analysis."[205]

Instead, the DEIS contains about five sentences that address the climate pollution impacts of the action alternatives only in the most vague and qualitative terms:

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[201] *See, e.g.*, D. DellaSala, *The Tongass Rainforest*, *supra* note 196 at 5.
[202] Intergovernmental Panel on Climate Change, *Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems, Summary for Policymakers* (Aug. 2019) at 7, 23, attached as Ex. TZ3. *See also* Law et al., *Land use strategies to mitigate climate change in carbon dense temperate forests,* Proceedings of the Nat'l Academy of Sciences, vol. 115, no. 14 (Apr. 3, 2018) at 3663 ("Proven strategies immediately available to mitigate carbon emissions from forest activities include . . . reducing emissions from deforestation and degradation."), attached as Ex. TZ4.
[203] *See* DEIS at 49.
[204] DEIS at 48.
[205] DEIS at 48. *See also id*. at 50 ("The relationship between timber harvests, reforestation, wood building materials, and the net storage of carbon is *complicated*.") (emphasis added).

> Both of the action alternatives involve old-growth and young-growth timber harvest along with road construction which would result in a net release of GHG and other pollutants into the atmosphere through varying amounts of road construction, timber harvest, use of administrative vehicles of all kinds, mining, recreation development and use, and other land management actions. Some proposed activities involve removing vegetation, grading and contouring the ground, hardening roads, extraction of materials such as gravel, soil, and rock, and the construction of bridges, all of which require fossil fuel-burning machinery and an increase in construction vehicle traffic for the next 15-year period. All these construction activities would increase GHG and other fossil fuel combustion emissions.
>
> Effects of timber harvest and roads in Alternatives 2 and 3 combined with effects of climate change could exacerbate adverse effects of peak streamflow increases on aquatic resources.[206]

In short, the Forest Service's complete analysis is that the action alternatives would increase GHG emissions. That analysis fails to quantify the climate impacts, nor does it even try to provide the public or the decision-maker with a sense of the scale of the climate harm. It does not permit a comparison among alternatives, nor does it identify measures to mitigate those impacts.

The Forest Service's approach violates NEPA. There is no loophole in NEPA allowing agencies to turn a blind eye to potential impacts because doing so is "complex" or "complicated." To the contrary, federal courts have long ruled that NEPA requires agencies to make reasonable estimates of potential impacts. "Reasonable forecasting and speculation is . . . implicit in NEPA, and we must reject any attempt by agencies to shirk their responsibilities under NEPA by labeling any and all discussion of future environmental effects as 'crystal ball inquiry.'"[207] "If it is reasonably possible to analyze the environmental consequences in an [EIS], the agency is required to perform that analysis."[208] "NEPA analysis necessarily involves some 'reasonable forecasting,' and ... agencies may sometimes need to make educated assumptions about an

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[206] DEIS at 51. *See also id.* at 50 ("construction activities" including roads, trails, quarries, etc., "would increase GHG and other fossil fuel combustion emissions, airborne dust, and particulate matter from wood burning.").

[207] *Scientists' Inst. for Pub. Info., Inc. v. Atomic Energy Comm'n*, 481 F.2d 1079, 1092 (D.C. Cir. 1973). *See also City of Davis v. Coleman*, 521 F.2d 661, 676 (9th Cir. 1975) (because "the basic thrust of an agency's responsibilities under NEPA is to predict the environmental effects of proposed action before the action is taken and those effects fully known . . . . [r]easonable forecasting and speculation is . . . implicit in NEPA.").

[208] *Kern v. U.S. Bureau of Land Mgmt.*, 284 F.3d 1062, 1072 (9th Cir. 2002) (finding both EIS and later EA inadequate under NEPA).

uncertain future."[209] "While foreseeing the unforeseeable is not required, an agency must use its best efforts to find out all that it reasonably can."[210]

Here, the Forest Service did not use its "best efforts" to address climate impacts. Rather it invested no effort, instead summarily concluding – without evidence or analysis – that it need perform no analysis at all. The agency's conclusion is arbitrary and capricious.

The only example the Forest Service provides for complexity relates to the effects of carbon stored in wood products. The DEIS notes that "carbon is stored in building materials, but the storage value does not last as long as a living old-growth tree, as carbon stored in buildings generally outlives its usefulness or is replaced within decades (Law et al. 2018)."[211] But the article by Dr. Law that the Forest Service cites disproves the agency's point. Dr. Law concludes that those carbon storage impacts can be estimated, accounted for, and factored into a model that calculated the net amount of carbon lost due to forest logging in Oregon over two five-year periods.[212] This is precisely the type of analysis the Forest Service should, and could, have undertaken for the DEIS.

Similarly, Dr. DellaSala's 2016 report addressed carbon stores from wood products and concluded that logging Tongass old-growth forest under the 2016 Forest Plan would result in net annual CO2 emissions totaling between 4.2 million tons and 4.4 million tons, depending on the time horizon chosen.[213] The Bureau of Land Management a decade ago completed an EIS for its Western Oregon Resource Management Plan in which that agency also predicted the net carbon emissions from its forest and other resource management programs.[214] Because agencies and academics have quantified and compared the carbon emissions of alternative logging proposals, the Forest Service cannot fail to undertake a similar analysis on the basis that it is too "complex" or "complicated."

The Forest Service failure to address or acknowledge that there are peer-reviewed scientific approaches to estimating net climate damage caused by logging temperate forests is an independent NEPA violation. NEPA requires agencies to explain opposing viewpoints and their

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[209] *Sierra Club v. FERC*, 867 F.3d 1357, 1374 (D.C. Cir. 2017) (quoting *Del. Riverkeeper Network v. FERC, 753 F.3d 1304,* 1310 (D.C. Cir. 2014)).
[210] *Barnes v. United States Dep't of Transp.*, 655 F.3d 1124, 1136 (9th Cir. 2011) (internal quotation marks omitted)).
[211] DEIS at 50.
[212] *See* Law et al., *Land use strategies* at 3664 ("Our LCA [life-cycle assessment] showed that in 2001–2005, Oregon's net wood product emissions were 32.61 million tCO2e [tons of carbon dioxide equivalent in net GHG emissions] (Table S3), and 3.7- fold wildfire emissions in the period that included the record fire year (15) (Fig. 2). In 2011–2015, net wood product emissions were 34.45 million tCO2e and almost 10-fold fire emissions, mostly due to lower fire emissions.").
[213] DellaSala at 14.
[214] *See* Bureau of Land Management, Western Oregon Proposed RMP Final EIS (2009) at 165-181.

rationale for choosing one viewpoint over the other.[215] Courts will set aside an EIS where the agency fails to respond to scientific analysis that calls into question the agency's assumptions or conclusions.[216] Here, while the DEIS cites Dr. Law's and Dr. DellaSala's reports, the agency fails to address either report's key finding that the life-cycle impacts of forest logging can be estimated and quantified. The agency's failure to address these studies violates NEPA.

We note that the 2016 Tongass Forest Plan Amendment declined to undertake a quantitative assessment of climate impacts because although such a "quantitative (i.e., numeric) assessment is feasible, . . . the quantitative results would include a large amount of error or uncertainty, such that the calculated differences between the alternatives would be difficult to discern."[217] While we reject that EIS's contention that some uncertainty renders quantification useless, we note that the Forest Service declined to address climate impacts at the Forest Plan level in part because "it is unknown when forests will be harvested or the extent of harvest that would occur at any particular time . . . for any alternative."[218] That uncertainty is not present here. The Central Tongass Project proposes a specific amount of logging (230 million board feet) including 150 million board feet of old-growth on a schedule. Now that the agency has the information it lacked at the Plan level, it cannot kick the can down the road again based on uncertainty about the scope of logging.

We note that the DEIS carefully quantifies the economic benefits of logging – a complex task – while ignoring the climate costs. The DEIS tallies the "[a]nnualized timber industry and associated jobs" and direct income.[219] Yet the Forest Service fails not only to estimate the volume of climate emissions, it fails to weigh the economic benefits of the project against the costs of climate change, which can be estimated using the Interagency Working Group's global estimate of the social cost of carbon.[220] Once an agency chooses to "trumpet" a set of benefits, it also has a duty to disclose the related costs.[221] "There can be no hard look at costs and benefits unless all costs are disclosed."[222]

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[215] 40 C.F.R. § 1502.9(b) (requiring agencies to disclose, discuss, and respond to "any responsible opposing view").
[216] *See Ctr. for Biological Diversity v. U.S. Forest Serv.*, 349 F.3d 1157, 1168 (9th Cir. 2003) (finding Forest Service's failure to disclose and respond to evidence and opinions challenging EIS's scientific assumptions violated NEPA); *Seattle Audubon Soc'y v. Moseley*, 798 F. Supp. 1473, 1482 (W.D. Wash. 1992) ("The agency's explanation is insufficient under NEPA – not because experts disagree, but because the FEIS lacks reasoned discussion of major scientific objections."), aff'd sub nom. *Seattle Audubon Soc'y v. Espy*, 998 F.2d 699, 704 (9th Cir. 1993) ("[i]t would not further NEPA's aims for environmental protection to allow the Forest Service to ignore reputable scientific criticisms that have surfaced").
[217] Forest Service, Tongass Land and Resource Management Plan, Final EIS (2016) at 3-21.
[218] *Id.*
[219] DEIS at 67-68 (estimating that the proposed action would result in precisely $34,243,540 in "direct income").
[220] *See High Country Conservation Advocates v. U.S. Forest Serv.*, 52 F. Supp. 3d 1174, 1190-93 (D. Colo. 2014).
[221] *Sierra Club v. Sigler*, 695 F.2d 957, 979 (5th Cir. 1983).
[222] *Id.*

Finally, the Forest Service cannot allege that it need not quantify the climate impacts of logging, hauling, and road construction by relying on NEPA regulations concerning "incomplete or unavailable information."[223] Those NEPA provisions require the agency to identify the information as such, to "make clear that such information is lacking," and nonetheless include the information in the EIS if the overall costs of obtaining it are not "exorbitant" and the information is "essential to a reasoned choice among alternatives."[224] The DEIS makes none of these required findings. Further, given the importance of the Tongass for carbon storage, it is essential for the Forest Service to disclose such impacts in order to understand whether the climate damage caused by logging outweighs any alleged economic benefits of logging. Only then can the no action and action alternatives be placed in sharp relief, which is essential to the comparison and analysis of alternatives.

XII. THE DEIS FAILS TO TAKE A HARD LOOK AT IMPACTS TO ROADLESS AREAS.

The DEIS acknowledges that there are "43 IRAs [Inventoried Roadless Areas] within the project area."[225] The Forest Service dismisses impacts to each and every roadless area because no roads will be constructed within them.[226] This despite the fact that the DEIS admits that logging, the construction of trails, including for OHV use, and other actions, "could" occur in one, or more, or all, of the roadless areas within the project area.

The DEIS fails to include a map of IRAs, nor does it identify whether multiple project components may occur in one or more IRAs. For example:

- "recreation activities, such as winter trail designations, *could* occur in, or near, inventoried roadless areas. The activities . . . would allow travel into the IRAs . . . snowmobiles, or other off-highway vehicles."[227]

- "The action alternatives include dispersed recreation activities, three-sided shelters and beach access, which *could* occur in IRAs."[228]

- "Watershed improvement activities which may include *some timber harvest* are also included in the action alternatives."[229]

The DEIS thus anticipates that IRAs could be impacted by new trails, an increase in motor vehicle use, the construction of new facilities, and timber harvest. Although these activities are

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[223] 40 C.F.R. § 1502.22.
[224] *Id*. § 1502.22(a).
[225] DEIS at 51.
[226] DEIS at 52 ("No direct impacts to IRAs are expected from timber harvest or road construction for any of the alternatives.").
[227] DEIS at 52 (emphasis added).
[228] DEIS at 52 (emphasis added).
[229] DEIS at 52 (emphasis added).

not always prohibited by the Roadless Rule, they may still degrade roadless characteristics, which the Rule defines to include

> (1) High quality or undisturbed soil, water, and air; (2) Sources of public drinking water; (3) Diversity of plant and animal communities; (4) Habitat for threatened, endangered, proposed, candidate, and sensitive species and for those species dependent on large, undisturbed areas of land; (5) Primitive, semi-primitive non-motorized and semi-primitive motorized classes of dispersed recreation; (6) Reference landscapes; (7) Natural appearing landscapes with high scenic quality; (8) Traditional cultural properties and sacred sites; and (9) Other locally identified unique characteristics.[230]

Trail construction and use (especially by motor vehicles), and the noise, air pollution, and other impacts that accompany such use, the building of recreational structures, and logging could degrade many of these values, including naturally appearing landscapes, sacred sites, habitat for sensitive species, and undisturbed soil. Further, the DEIS does not address whether any of these activities, especially the construction and use of motor vehicle trails within the IRAs, may be incompatible with the designation of these areas as wilderness.

In sum, the Forest Service fails to address these impacts relative to the inventoried roadless area(s) that may be impacted. Nor does the DEIS identify which areas could be impacted by which type of project. Any subsequently prepared NEPA document must remedy the lack of analysis of impact to roadless areas and characteristics.

XIII. THE DEIS UNDERESTIMATES IMPACTS TO WILDLIFE.

An important Forest-wide Wildlife Standard is to provide the abundance and distribution of habitat necessary to maintain viable populations of existing species well-distributed in the planning area.[231] There are three references in the DEIS to maintaining "viable, well-distributed populations" of wildlife,[232] but no acknowledgement that that is the standard that the Forest Service must demonstrate that this directive will be attained for species at issue for this project. The FEIS must acknowledge the standards that apply to this project from the Forest Plan and NFMA and implementing regulations, and explain how the project will comply with them. As noted, compliance with a habitat threshold that lacks the scientific basis to serve as a proxy for ensuring viable, well-distributed wildlife populations will not suffice to demonstrate compliance with NFMA.

The comments below address marten, deer and wolves specifically, but the DEIS's analysis of all wildlife species is compromised by the lack of sufficient specificity noted above - especially endemic species whose viability is highly dependent on site-specific conditions. The analysis is inadequate to support the conclusion that this project will maintain viable, well-distributed populations of wildlife in general.

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[230] 36 C.F.R. § 294.11 (Jan. 12, 2001).
[231] 2016 Tongass Forest Plan at 4-85.
[232] DEIS at 111, 136, 139.

A. Marten

From the information available in the DEIS, it appears that the Central Tongass project would likely have unacceptable impacts to marten in the project area. Due to the programmatic nature of the analysis, it is impossible to quantify those effects with any specificity because the precise logging and road locations are unknown, preventing any rigorous assessment of remaining habitat quality and connectivity on any meaningful scale. But in general we concur with the Forest Service that impacts to marten will be "major," and available information indicates that the project area will likely not support viable, well-distributed populations of marten across the landscape.

1. Habitat

Large, continuous blocks of old-growth forest are very important for martens, which are extremely sensitive to the loss and fragmentation of mature forest habitat and rarely occupy landscapes after 30 percent of the mature forest has been harvested.[233] Martens especially select for higher volume old-growth forest types at low elevation (<250 meters).[234]

The DEIS identifies 30% forest removal as an important threshold for marten, but fails to note the fact that they rarely occupy these areas where the 30% threshold has been crossed. Areas "rarely occupied" by a species can be safely assumed to be areas where viable, well-distributed populations do not occur. There are numerous such areas that already exist within the project area, and this project will create more such areas. The Central Tongass DEIS incorrectly applies habitat thresholds developed for deer to marten. In other words, deer habitat requirements are used as an umbrella for marten habitat standards, when often marten are considered umbrella species in old growth forests. Marten are more dependent on prey species densities, whereas deer foraging habitat thresholds are based on deer foraging behavior and needs. Rather, the body of research available for Pacific marten, and marten species in general, indicates that both forest structure and landscape pattern are important indicators for marten.[235] This research also indicates that *less than* 25% open canopy created by both clearcuts and natural openings is the threshold for marten in areas greater than or equal to 9 km^2. When we apply these thresholds to islands, we also have to consider edge effects caused by landscape heterogeneity along shorelines. Marten studies across North America, including Southeast Alaska, indicate marten prefer high gradients of forest complexity that are reliant on a number of features. The amount of unsuitable habitat, as mentioned above, does impact marten occupancy at 25% thresholds.[236] Marten also rely on structurally complex understory, particularly in winter. This, more than snow depth, along with prey availability, are variables used to assess the quality of marten habitat and

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[233] Wildlife Resource Report (WRR) at 130, citing Chapin et al. 1998, Hargis et al. 1999, Potvin et al. 2000, Moriarty et al. 2016a) (emphasis added).
[234] WRR at 130.
[235] Hargis, C.D., J.A. Bissonette, and D.L. Turner. 1999. The influence of forest fragmentation and landscape pattern on American martens. Journal of Applied Ecology 36: 157-172.
[236] Dumyahn, J., P. Zollner, and J. Gilbert. 2005. Winter Home-range Characteristics of American Marten (Martes Americana) in Northern Wisconsin. American Midland Naturalist. 158. 382-394.

persistence.[237] Southeast Alaska creates very complex habitat characteristics because of the diversity of prey species shifting across islands.[238] *Microtus spp*. (voles), primary prey sources for marten, are available disproportionately across the Tongass, with some islands having more species of *Microtus* than others. *Tamiasciurus spp.* (squirrels) are another prey species distributed unevenly across the Tongass. These ranges impact the range and distribution of Pacific marten and American marten.

Of the most favorable "deep snow" marten habitat, high POG below 800 feet, only 76% currently remains in the project area as a whole, and many VCUs have between 21% and 70% HPOG remaining on NFS lands.[239] Marten are already nearing the critical 30% threshold for their preferred habitat project area-wide. The DEIS notes that this project will severely compromise preferred marten HPOG habitat below 250 meters:

> In VCUs where the percentage of historic average winter and deep snow marten habitat remaining would be below 70 percent under either alternative there would be an increased potential for marten population declines. The potential would be even more elevated where the percentages of habitat that would remain would be low in adjoining VCUs. This situation is particularly evident on north Zarembo where both VCUs would be below 50 percent of the historic average winter and deep snow marten habitat; and one of these VCUs is already below 50 percent deep snow marten habitat remaining.
>
> On Mitkof Island four adjoining VCUs would all fall below 70 percent remaining of average winter marten habitat, and deep snow habitat would be below 50 percent remaining. West Kupreanof is similar to Mitkof Island. Wrangell Island would also have some VCUs that adjoin each other that would be below 70 percent average winter marten habitat and 50 percent deep snow marten habitat. Two VCUs on Kuiu Island would also fall below 70 percent of average winter habitat though they are not immediately adjacent to each other and there are several VCUs adjoining each other that are currently below 70 percent deep snow marten habitat and one of these would fall below 50 percent remaining.[240]

Additionally, this project will adversely impact "average" marten habitat – POG below 1500 feet. The Forest Service has identified five VCUs (4370, 4550, 4560, 4570 and 4600) in the project area where removal exceeds 33%, and an additional 16 VCUs that will meet that criterion if this project proceeds, including adjoining VCUs which exacerbate the fragmentation problem

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[237] Allen, A.W. 1982. Habitat Suitability Index Models: Marten. U.S.D.I. Fish and Wildlife Service. FWS/OBS-92/10.11. 9 pp.; Ben-David, M., Flynn, R. & Schell, D. 1997. Oecologia. 111: 280. https://doi.org/10.1007/s004420050236; Ruggiero, L.F., D.E. Pearson, S.E. Henry. 1998. Characteristics of American marten den sites in Wyoming. Journal of Wildlife Management 62(2):663–673; Buskirk, S. W. and R. A. Powell. 1994. Habitat ecology of fishers and American martens. Comstock Publishing Assoc. Cornell Univ. Press.
[238] S.O. MacDonald and J.A. Cook. Mammals and Amphibians of Southeast Alaska. 2007. Special Publication, Museum of Southwestern Biologist, University of New Mexico. Pp. 88-92.
[239] DEIS at 93.
[240] DEIS at 100-101.

for marten. Two more VCUs on Zarembo Island that are currently between 50-70% intact will fall below 50%.[241] Thus, a total of 23 VCUs will not include sufficient habitat to support viable marten populations if the project moves forward. Figure 9 visually depicts the areas of preferred marten habitat already decimated to or beyond the point where marten can be expected to rarely occur.[242]

The DEIS does recognize that "the relatively low amount of important marten habitat that could remain in certain VCUs would have the potential to cause localized declines in marten populations. Therefore, Alternatives 2 and 3 would have major effects to American marten as a Management Indicator Species."[243] What the analysis ultimately indicates, however, is that the project area as a whole cannot be expected to support viable, well-distributed populations of marten because of these major impacts to key marten habitat. There are no provisions to ensure viable populations in the numerous areas noted that will lack sufficient habitat, e.g., Zarembo, Mitkof, West Kupreanof, Etolin or Wrangell island. The Forest Service must demonstrate that any selected alternative contains sufficient habitat to support viable, well-distributed populations of wildlife, including marten. Because the DEIS fails to do so, the proposed action alternatives will violate NFMA.[244]

2. *Legacy Standards and Guidelines*

The DEIS notes that the Legacy standards and guidelines within the Forest Plan were developed in part to address marten habitat concerns.[245] These standards and guidelines only apply to harvest units greater than 20 acres in VCUs where 33% or more of POG was harvested by 2005, or more than 67% of POG is projected to be harvested by the end of the Forest Plan planning horizon.[246] That is, they only apply in areas that have already been logged, or will be logged, past the point where they can serve as suitable marten habitat. The Legacy standards serve to hopefully retain a measure of connectivity and decrease the effects of fragmentation by facilitating the movement of marten through unsuitable habitat. They don't add or create suitable habitat themselves.

The DEIS states that two legacy VCUs are identified in the Forest Plan that are in the project area, VCU 4550 and VCU 4570. That was true as of 2008. As noted above, however, there are actually 23 VCUs in the project area that will trigger the application of the Legacy standards and guidelines, including numerous adjoining VCUs, painting a much more bleak outlook for marten than suggested by the reference to just two VCUs in sufficiently beleaguered condition as to trigger the Legacy standards. To comply with NEPA, any subsequently prepared NEPA document must address this inconsistency and address the potentially significant impacts to marten.

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[241] *Id*.
[242] DEIS at 94.
[243] DEIS at 92.
[244] *See* Forest-wide Standard WILD1 II.B, 2016 Tongass Forest Plan at 4-85; 16 U.S.C. § 1604(i).
[245] 2016 Tongass Forest Plan at 4-86-87.
[246] *Id*.

3. *Mortality*

Increased road densities associated with timber harvest activities have improved trappers' access to furbearers' habitat in some locations, reducing their refugia and making the animals increasingly vulnerable to overharvest (Lowell 2014). The only regulatory mechanisms that ADF&G can enact is closing the season by emergency order. For that reason, maintaining unroaded refugia for martens is very important. Access is also provided via the shoreline.

The DEIS largely dismisses any consideration of legal and illegal marten harvest, or of road density as a proxy for assessing the risk posed by harvest to marten populations in the project area. This is despite the plain recognition that, at least up to a certain point such as 1.5 miles per square mile, road density correlates with harvest. The DEIS notes only that, after that point, ever-increasing road density may not continue to correlate with increased harvest.[247]

Further, while the DEIS mentions in passing road density and "motorized access" generally as potential threats to marten, the DEIS makes no attempt to account for the impacts of 128 miles of OHV routes.[248] Clearly, OHV routes will make it easier for those seeking marten pelts to set traps into new territory. New shoreline access and new pedestrian trails will also increase the ease of access for trappers. But the DEIS fails to disclose, or characterize, qualitatively or quantitatively, the nature of these compounding impacts on marten.

This does not constitute taking a "hard look" at road and trail density and mortality that may be expected from legal and illegal harvest over the course of 15 years in a large project area. Again, identifying the areas where logging and roadbuilding will occur is necessary to then calculate road density, distance from population centers, past harvest, and other relevant considerations in estimating legal and illegal harvest of marten in the project area. This information will factor into conclusions regarding whether viable, well-distributed marten populations can be expected on the landscape.

The DEIS does not address the fact that ADFG has not reopened the trapping season on Kuiu Island due to the high mortality rates of Pacific marten and American marten on Kuiu Island.[249] Up to 60% mortality occurs on Kuiu Island. The DEIS also states that population information is not known on Kuiu Island, however, researchers from ADFG and the University of New Mexico illustrated that the marten population on Kuiu Island is in decline.[250]

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[247] DEIS at 101.

[248] *See, e.g.*, DEIS at 100 (noting that "roads would further increase the road density and add to the potential for increased trapping pressure," but failing to address OHV routes); *id*. at 116 (stating very generally that "Changes in access ... would not be likely to cause effects to most species, except for species that … are hunted or trapped by humans," and mentioning "road construction" but not the opening of OHV trails as a 'change of access').

[249] Flynn et al., (2012) Population Dynamics, Movements and Habitat Selection of Martens on Kuiu Island, Southeast Alaska. Interim Wildlife Research Report. Alaska Department of Fish and Game. Juneau, AK.

[250] *Id.*

4. *Hybridization*

Pacific marten on Kuiu and Kupreanof Island hybridize. It is unknown whether this hybridization contributes to low population numbers on these islands, however, research indicates that the hybridization between these two species may be maladaptive.[251] Disturbance events, such as clearcut logging and loss of habitat, increase hybridization events.[252] Therefore, a mitigation strategy for maintaining viable populations of marten on Kuiu and Kupreanof islands must include management that addresses the impacts of hybridization on the declining and rare populations of Pacific marten across their global range, which is focused in Southeast Alaska and within the Central Tongass DEIS project area. Management prescriptions for maintaining viable populations of marten in lieu of hybridization focus on protecting landscapes where both species are located.

5. *Mitigation*

The Forest Service's recognition that this project would bring major impacts to marten and habitat seems to drive the inclusion of measures to reduce those impacts. Alternative 3 contains these provisions specific to marten on Kuiu island:

> **Gross unit pool, old growth:** On Kuiu Island, defer harvest of old growth in areas of High or Very High focal areas of use by marten. Koch (2016) mapped focal areas of use by marten on Kuiu Island using a resource selection function (RSF) model. Habitats were binned into five categories based on RSF scores, which are proportional to the probability of marten occurrence on the landscape. Five categories were used to map the scores on the RSF map as follows: very high (most important for marten), high, medium, low, and very low (least important).
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> **Gross unit pool, young growth:** On Kuiu Island, in areas of High or Very High focal areas of use by marten, the maximum size of any created young-growth opening for commercial timber harvest must not exceed 10 acres and a maximum removal of up to 35 percent of the acres of the original harvested stand is allowed. Commercial thinning is limited to 33 percent of the stand's basal area. A combination of the two treatments may be used, with no more than 35 percent of the total stand removed in either basal area and/or acres. TTRA and other administratively withdrawn areas do not count towards the stand's total acreage.[253]

These measures appear inadequate to address or significantly reduce the major impacts to marten from this project based on the best available science. First, while marten populations are very low on Kuiu island, mitigation is necessary on more that just one island in order to ensure viable and well-distributed marten populations across the landscape. As noted, marten habitat will also

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[251] Colella JP, EJ Johnson, JA Cook. (2018b) Reconciling molecules and morphology in North American Martes. Journal of Mammalogy: gyy140. DOI: https://doi.org/10.1093/jmammal/gyy140.
[252] Todesco et al., Hybridization and Extinction, Evolutionary Applications (2016).
[253] DEIS at 75.

face major impacts on Zarembo, Mitkof, West Kupreanof, Etolin and Wrangell islands. The Forest Service must identify more precisely where the habitat destruction is proposed, and then assess marten viability across the planning landscape using that information.

Additionally, we suggest using already-known indicators of preferred marten habitat (especially high POG below 800 feet, and also beach fringes, riparian corridors and POG below 1500 feet) in determining which areas to prioritize protecting. The resource selection function (RSF) model noted reflects habitat use that was observed on Kuiu island but with important constraints in terms of temporal and spatial survey scope.[254] Mitigation should not be limited to Kuiu Island and the RSF model from the Koch study should not be interpreted to exclude any key marten habitat on Kuiu Island that would otherwise be identified as likely to be used by marten pursuant to the numerous other marten studies referenced in the WRR.[255] Research indicates the Pacific marten from Kuiu Island is also present on Kupreanof Island,[256] so at the very minimum, any guidelines to protect Pacific marten on Kuiu Island should be applied to Kupreanof Island. We included the updated range map for Pacific marten and American marten. As another example of missing mitigation, the DEIS states that the "Etolin Island Biogeographic Province is considered a high-risk province for marten habitat because of the amount of past timber harvest (1997 Forest Plan FEIS, p. 4-118)."[257] Yet there is no assessment of the present implications of this observation, and nothing about the project (apart from the Kuiu provision in Alternative 3) that appears designed to account for it. For every alternative, any subsequently prepared NEPA document must explain how further logging and roadbuilding will effectively account for and manage the "high risk" for marten habitat that already exists in the project area.

In sum, we agree that impacts to marten from the proposed old-growth logging in Alternatives 2 and 3 would be "major."[258] But the Forest Service must explain how, in light of those major impacts to marten and habitat, marten populations will continue to be viable and well-distributed across the landscape. Failure to do so will violate NEPA and NFMA.

B. Deer

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[254] The paper cited in the project record, *Effects of demography on resource selection by martens on Kuiu Island, Alaska,* (Koch 2016), is a thesis manuscript "to be submitted to the peer-reviewed Journal of Wildlife Management," so as cited has not been peer-reviewed. The manuscript upholds the existing general understanding about preferred marten habitat, but its limitations in terms of identifying actual high-use marten areas throughout the island are discussed at pp.9-10 of the paper.
[255] *E.g.,* WRR at 130.
[256] Dawson, NG, JP Colella, MP Small, KD Stone, SL Talbot, JA Cook. (2017) Historical biogeography sets the foundation for contemporary conservation priorities for mesocarnivores (genus Martes) of Pacific Northwest. Journal of Mammalogy 98(3):715-730. Colella JP, RE Wilson, SL Talbot, JA Cook (2018a) Implications of introgression for wildlife translocations: the case of North American martens. Conservation Genetics 20(2): 153-166. DOI: https://doi.org/10.1007/s10592-018-1120-5.
[257] DEIS at 93.
[258] DEIS at 105.

High value winter habitat is the limiting factor for deer populations in the project area. There are 162,483 acres of high and moderately high value deer winter habitat in the project area, and this project could log up to 5,417 of those acres.[259]

Here again, the DEIS analysis fails to identify the specific locations where high or moderately high value deer winter habitat will be lost. The actual impacts of logging and roadbuilding on deer and habitat could vary widely depending on the location of those 5,417 acres, or more generally the 9,500 total acres of old growth that could be harvested from the old growth unit pool of 42,779 acres.

The Forest Service seems to have abandoned the novel view espoused in the POWLLA EIS that the post-project continued existence of 50% of the original (1954) habitat type will ensure that effects to deer will be "minor." The agency now states that "though there are no known thresholds for the amount of deer winter habitat required, reductions in this important deer winter habitat (high and moderately high value deer winter habitat) increase the risk of severe winters in not sustaining a healthy deer population in the long term, and may result in periodic declines from infrequent severe winters."[260]

We concur that there is no clear threshold for the amount of deer winter habitat required to maintain healthy deer populations, accounting also for both wolf predation and human subsistence use. We restate our recommendation on the POWLLA project, however, that the agency re-evaluate winter deer habitat and impacts of the chosen alternative using the large-tree (SD67) habitat type. Continued high-grading of large-tree old growth will have significant impacts on winter deer habitat and habitat for other wildlife species dependent on these forest types as well as affecting overall forest diversity.[261] The Forest Service must assess the impact of the actual harvest authorized by this project on this exceedingly rare habitat type – and to do that, it must specify where the logging and roadbuilding will occur.

The DEIS states that "the most important habitat for deer is high and moderately high value deer winter habitat (all POG less than 800 feet elevation on south facing slopes)."[262] Continuing to lump the rare SD67 habitat type in with other HPOG habitat types obfuscates the impacts that high-grading this habitat type will have on overall forest composition as well as on species that depend in particular on this habitat type for critical life functions – including Sitka black-tailed deer. We also reiterate that restricting the deep snow habitat to south-facing slopes is problematic because many deer do not have access to south-facing slopes, and deer inhabiting north-facing habitat are most affected by snow and most dependent on deep-snow habitat.

Finally, while there may not be a clear winter deer habitat threshold set forth, there is the applicable Alexander Archipelago wolf Forest Plan Standard directing the agency to provide,

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[259] DEIS at 84.
[260] DEIS at 76.
[261] Alaska Rainforest Defenders, et al., Comments on POWLLA DEIS at 40-41, June 18, 2018 (citing the comments of Dr. John Schoen); *see also* Albert, David M. & Schoen, John W. 2012, Use of Historical Logging Patterns to Identify Disproportionately Logged Ecosystems within Temperate Rainforests of Southeastern Alaska, 27 Conservation Biology, No.4, 774-784.
[262] DEIS at 76.

where possible, sufficient deer habitat capability to first maintain sustainable wolf populations, and then to consider meeting estimated human deer harvest demands.[263] This generally equates to the habitat capability to support 18 deer per square mile.[264] This Standard is tied to the two overarching Goals and Objectives for Wildlife for the entire Forest Plan:

> Maintain the abundance and distribution of habitats, especially old-growth forests, to sustain viable populations in the planning area; and
>
> Maintain habitat capability sufficient to produce wildlife populations that support the use of wildlife resources for sport, subsistence, and recreational activities.[265]

The DEIS briefly notes in its analysis of wolves that 29 of the 40 WAAs in the project area do not provide the habitat capability to support 18 deer per square mile.[266] But the DEIS fails to examine why this is the case, or to discuss how different project alternatives, designs or actions may promote compliance with this important wildlife standard. Instead, the Forest Service simply concludes that the action alternatives would further reduce the theoretical deer density, increasing the risk that a severe winter would cause declines in the deer population.[267] This observation falls woefully short of taking the requisite "hard look" at the impacts of the proposal and a reasonable range of alternatives.

C. The DEIS's Analysis Of The Alexander Archipelago Wolf Violates NEPA And NFMA, And Is Arbitrary and Unlawful.

The Central Tongass Project—which authorizes massive levels of old-growth logging and road construction across vast swaths of Mitkof, Kupreanof, Kuiu, Wrangell, Zarembo and Etolin islands over the next 15 years—will cause substantial harms to the Alexander Archipelago wolf in Game Management Unit 3 (GMU 3) which overlaps the Project Area. Yet the DEIS arbitrarily determines that impacts to the wolf will only be "moderate," failing to provide a clear or rational basis for this determination. On multiple counts as detailed below, the DEIS omits critical information relevant to the Project's harms to the wolf, fails to justify its conclusions, and reaches conclusions unsupported by the record. As such, the Forest Service's analysis of the adverse impacts of the Central Tongass Logging Projects on the Alexander Archipelago wolf fails to take the hard look NEPA requires and is inadequate, arbitrary, and unlawful.

1. The DEIS fails to address important information from the USFWS indicating that Alexander Archipelago wolf populations in the Project Area already face substantial threats.

The DEIS fails to disclose important information from the USFWS's 2015 Status Review and 2016 Endangered Species Act listing determination for the Alexander Archipelago wolf, in which the Service determined that wolves in the GMU 3 region already face "intermediate" levels of stressors: "the primary stressors for wolves in GMU 3 occur at intermediate levels

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[263] 2016 Tongass Forest Plan at 4-91.
[264] *Id*.
[265] 2016 Forest Plan at 2-6.
[266] DEIS at 138.
[267] DEIS at 146.

compared to other GMUs and Regions."[268] Key sources of stress to wolves in GMU 3 identified by the Service's Status Review include: (1) substantial prior logging (i.e., 14% of the region's forests had been logged) which has reduced deer habitat capability by 13% to 23% since 1954;[269] (2) the highest scheduled levels of future logging on the Tongass National Forest; (3) wolf harvest levels that are higher than in any other GMU, with the mean reported annual harvest estimated at 21% of the population, not including unreported harvest; and (4) the second highest ratio of shoreline to land area (0.62 compared with 0.81 for GMU 2), which allows more boat access for hunters and trappers and thus increases wolf mortality risks.[270]

In addition, USFWS warned of the threat from an approved deer management plan for GMU 3 that, if activated, would cull up to 80 percent of the region's wolves and would increase the vulnerability of wolves on Prince of Wales Island which are already in peril:

> Intensive management of black-tailed deer, which includes the culling of wolves with the aim of increasing deer populations and deer harvest by humans, is authorized for GMU 1A (ADFG 2013a) and in GMU 3 (ADFG 2013b). Currently, these programs are inactive, but operational plans exist and could be implemented in the future… In GMU 3, the treatment area constitutes 22% of the total land area and is located in the northern portion of the unit including Woewodski, Mitkof, and part of Kupreanof Island (ADFG 2013b, p. 6). Within the GMU 3 treatment area, up to 80% (or ~50 wolves in 5–6 packs) would be removed; duration of the culling effort would be a minimum of five years (ADFG 2013b, pp. 8–9).[271]
>
> Although the program currently is inactive, if implemented the GMU 3 wolf population would be reduced, given that it is the goal of the program, potentially having an effect on the GMU 2 population because GMU 3 provides the most reasonable transit path for wolves to move or disperse between the mainland and GMU 2 (Figure 2). Therefore, maintaining or reducing current rates of wolf harvest in GMU 3 would benefit the rangewide population of Alexander Archipelago wolves; an increase in mortality rates likely would lower immigration rates to GMU 2, which apparently are uni-directional (Breed 2007, p. 22), thereby increasing the vulnerability of the GMU 2 wolf population.[272]

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[268] U.S. Fish and Wildlife Service, Species status assessment for the Alexander Archipelago wolf (*Canis lupus ligoni*), Version 1.0, December 2015, Alaska Region, Anchorage, Alaska. 162 pp, at 120.
[269] According to Albert & Schoen 2007 (Table 5), Kupreanof and Mitkof Islands in GMU 3 lost 16 percent of productive old-growth forests and 48 percent of large-tree forests; and Etolin and Zarembo Islands lost 15 percent of productive old-growth forests and 50 percent of large-tree forests.
[270] U.S. Fish and Wildlife Service, Species status assessment for the Alexander Archipelago wolf (*Canis lupus ligoni*), Version 1.0, December 2015, Alaska Region, Anchorage, Alaska. 162 pp, at Table 24.
[271] *Id.* at 88.
[272] *Id.* at 120.

The DEIS must incorporate this critical information for adequately assessing the cumulative impacts of the Project on wolf populations in GMUs 3 and 2.

2. The DEIS fails to analyze the Project's site-specific impacts to wolves.

As discussed above, the DEIS analysis fails to identify the precise location, configuration, sizes, and timing of the logging and road construction activities, including failure to identify the specific locations where high or moderately high value deer winter habitat will be lost. The actual impacts of logging and roadbuilding on wolf mortality and reproductive success, wolf habitat, habitat connectivity, and Sitka black-tailed deer prey could vary widely depending on the location of logging projects and roads, and the DEIS's failure to provide required specificity prevents a rigorous impacts assessment. Wolf experts have previously faulted the Forest Service for failing to be site-specific in the EIS for the Prince of Wales Logging Project, explaining that the distribution of forest stands and connectivity between stands "can have dramatic effects on the survivorship" of wolves because they have large home range territories.[273] For these reasons, they explained that the site-specific "geography of the proposed logging . . . is essential to evaluating the impact[s]" on wolves.[274]

3. The DEIS fails to incorporate the recommendations from the Wolf Habitat Management Program.

The DEIS claims that it has incorporated treatments from the Wolf Habitat Management Program into its action alternative.[275] However, the DEIS incorporates only three recommendations from the Wolf Habitat Management Program, all related to young-growth thinning, while failing to incorporate the Program's recommendations related to road management, wolf mortality, human dimensions, and research and monitoring. Furthermore, the DEIS fails to disclose that the three incorporated thinning recommendations have not been shown to produce population-level benefits to deer, and therefore to wolves, as acknowledged the Wolf Habitat Management Program.[276] The DEIS further fails to disclose new research by Roffler and colleagues (2018) that found that young-growth thinning treatments have not been effective in improving habitat for wolves.

In a study of the habitat preferences of Alexander Archipelago wolves, Gretchen Roffler, a wildlife research biologist with ADFG, and colleagues concluded that young-growth thinning treatments, conducted to improve habitat value in seral forests, do not enhance habitat for

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[273] *See generally* J. Cook et al. Statement on DEIS Prince of Wales Landscape Level Analysis, and attachments at PDF 7 (Jun. 11, 2018) (Cook Comments).
[274] *Id*. at 7.
[275] DEIS at 20.
[276] Wolf Technical Committee, Interagency Wolf Habitat Management Program: Recommendations for Game Management Unit 2, Management Bulletin R10-MB-822, USDA Forest Service, USDI Fish and Wildlife Service, and Alaska Department of Fish and Game (2017) at 6 ("Habitat management has been shown to reduce the impacts of post-clearcut forest succession on deer forage though population-level benefits to deer remain undocumented.").

wolves.[277] During fall and winter, wolves avoided clearcuts more than 30 years old as well as thinned young-growth "indicating that young-growth forest has a limited time frame of potential use by wolves, similar and likely related to predictions for use by deer (≤30 years post clearcut)."[278] They further explained:

> Young growth treated with pre-commercial thinning is intended to enhance deer habitat by delaying stem exclusion and prolonging forage production. However, wolves avoided thinned forest during winter, and did not display patterns of selection for thinned forest stands during other seasons confirming previously described patterns of avoidance of second growth in the stem exclusion phase, in particular pre-commercially thinned stands. Thus far, the benefits of thinning treatments on maintaining understory vegetation have proven to be short-term (5–10 years), diminishing the potential for sustaining wildlife through the long-lasting stem exclusion phase. In this study we demonstrate that thinning treatments do not thus far appear to enhance habitat for wolves.[279]

Roffler et al. (2018) warned that "the amount of habitat available to wolves could decline with an increasing proportion of the forest transitioning to the stem exclusion phase, with potential population-level consequences for wolves."[280]

Although the DEIS briefly asserts that "a wolf mortality concern has not been identified in the project area"[281] as a justification for not implementing the full recommendations of the Wolf Habitat Management Program, the current threats to wolf populations in GMU 3, as well as future impacts from this Project, do raise wolf mortality concerns for this region, as detailed below.

4. The DEIS fails to analyze the Project's impacts on wolf den sites and incorporate significant new published research and recommendations for wolf den site protection.

The DEIS acknowledges that "Alternatives 2 and 3 have the potential to directly and indirectly affect den sites" and that "project activities under either action alternative could cause disturbance to denning."[282] Yet the DEIS fails to analyze the Project's impacts to wolf dens or incorporate new published research and recommendations for wolf den site protection.

Importantly, the DEIS fails to incorporate new research by Roffler and Gregovich (2019) which found that Alexander Archipelago wolves use larger core areas during the breeding season than previously assumed, and recommends that the wolf den buffer be expanded from the 1,200 feet

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[277] Roffler, Gretchen H. et al., Resources selection by coastal wolves reveals the seasonal importance of seral forest and suitable prey habitat, 409 Forest Ecology and Management 190 (2018).
[278] *Id.* at 197.
[279] *Id.* at 197.
[280] *Id.* at 199.
[281] DEIS at 139.
[282] *Id.* at 139.

to at least 2,400 feet.[283] The study reported that the distance from active Alexander Archipelago wolf den sites to the edge of core habitat ranged from 1,186 to 6,326 meters (~3,900 to 21,000 feet), and for breeding wolves the core use area ranged from 734 to 2,308 meters (~2,400 to 7,600 feet) from the den site. Significantly, the study concluded that "all distances exceeded the existing recommended den buffer distance" and further that "[w]olf managers should recognize the current protection buffer around dens constitutes only a portion of the core area used by breeding wolves, and habitat alterations near den sites may force breeding wolves to use sub-optimal habitat they would normally avoid."[284]

The study made a number of important specific recommendations for "land managers working to protect den sites" that the DEIS must assess and incorporate: (1) For all wolves associated with an active den, the median distance between the den and the core home range edge was 3,756 meters (~12,300 feet); therefore, land managers working to protect den sites should consider expanding the much smaller guideline den site buffers in place now to this larger size; (2) the shape of the protected polygon surrounding the den should be selected to maximize high quality denning habitat: flat, low elevation terrain, in old growth forests, near freshwater and distant from high density road areas; importantly, the den buffer width should not be less than 734 m (~2,400 feet); (3) to maintain foraging habitat for wolves during denning season, the proportion of old growth forest should not be reduced below the current values (61% of the core home range area for wolves associated with an active den); (4) the recommended period for seasonal management activity restrictions around active dens is 15 March to 15 July based on earlier work by Person and Russell (2009; Wolf Technical Committee 2017); however, wolves were documented during this study at dens as late as 21 July, and the mean den occupancy was nearly two months; thus extending the restriction period to late July would be a conservative management action; (5) because wolves display a flexible response to road density throughout the year by avoiding areas with high road densities during denning season, but selecting these areas during winter (Roffler et al. 2018), timing is also a consideration in road closures as a management action.[285]

5. *The DEIS's analysis of cumulative impacts on wolves is inadequate.*

The DEIS impermissibly fails to provide a clear conclusion regarding the overall cumulative effects of the Project and past, present and reasonably foreseeable actions on wolves, merely stating that "there would be cumulative effects."[286] With regard to roads, the DEIS vaguely states that "roads would further increase the road density and add to the potential for increased hunting and trapping pressure."[287] The DEIS is equally vague with regard to the cumulative impacts from

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[283] Roffler, Gretchen H. & David P. Gregorovich, Wolf space use during denning season on Prince of Wales Island, Alaska, Wildlife Biology, doi.org/10.2981/wlb.00468 (2019).
[284] *Id.* at 1.
[285] *Id.* at 9.
[286] DEIS at 145.
[287] *Id.* at 145.

timber harvest on wolves: "The alternatives would further reduce the theoretical deer density, thus increasing the risk that a severe winter would cause declines in the deer population."[288]

As discussed above, the DEIS also fails to address or acknowledge the cumulative impacts from the approved Prince of Wales Logging Project which will have significant adverse impacts on wolves and deer due to its massive proposed levels of old-growth clearcutting and road-building. The DEIS also fails to address and acknowledge the potential impacts of the nearby South Revilla Project which would authorize harvest of up to 46 million board feet of timber largely from old-growth logging, and further degrade wolf habitat. Nor does the DEIS address the impacts of the proposed rollback of the roadless rule for wolves.

6. The DEIS fails to include any monitoring program for wolves to assess the impacts from the Project.

Alexander Archipelago wolves in the Project Area are vulnerable to adverse impacts from the massive levels of logging and road-building proposed by the Project, yet the DEIS proposes no monitoring for wolves to track and assess the harms. As noted by USFWS in its 2015 Status Review, the status and trend of the GMU 3 wolf population is unknown, and the USFWS has only a rough estimate of the wolf population of 150–350 wolves. Thus, the DEIS should require implementation of the recommendation from the Wolf Habitat Management Program and Forest-wide Standards and Guidelines to conduct interagency monitoring of wolf populations on the Forest for GMU 3.

7. The DEIS's determination that the impacts from the Project on the Alexander Archipelago wolf would only be "moderate" is arbitrary.

The DEIS's impacts analysis makes clear that the Project will cause substantial adverse impacts to wolf populations from timber harvest through old-growth logging and subsequent reductions in deer densities, and from road-building by improving access for hunters and trappers. Yet the DEIS determines the Project's impacts to the Alexander Archipelago wolf would only be "moderate" without providing a rational explanation connecting this determination to its impacts analysis and the evidence in the record.

In regard to evaluating the impacts of timber harvest, the DEIS uses the Interagency Deer Model Habitat Capability outputs by WAA, calculated to deer density (deer per square mile), as the indicator. The DEIS notes that the Forest Plan Forest-wide Standard and Guideline "emphasizes providing, where possible, sufficient deer habitat capability to first maintain sustainable wolf populations then to meet estimated human deer harvest demands" which is "generally considered to equate to the habitat capability to support 18 deer per square mile (using habitat capability model outputs) in biogeographic provinces where deer are the primary prey of wolves."[289]

Because 29 of 40 WAAs in the Project Area have deer habitat capability less than 18 deer per square mile, and all but two WAAs where timber harvest is planned have deer habitat capability below 18 deer per square mile, the DEIS concludes that this "suggests the project would result in

[288] *Id.* at 145.
[289] *Id.* at 141.

higher risk that there could be insufficient numbers of deer for sustainable wolf populations and human harvest. This concern exists despite the availability of alternative prey (such as moose and salmon) due in part to the fact that alternative prey may delay a decline in wolf numbers."[290] In addition, the DEIS finds that deer habitat capability would be further lowered by the Project's logging in 13 WAAs, including large-scale declines in areas such as Portage Bay (18.6 percent from the existing condition at stem exclusion estimated at Year 2045), Zarembo (14.8 percent reduction), and Mitkof (11.5 percent reduction). The DEIS reports that two of the top three most affected WAAs (Zarembo and Mitkof) also receive a substantial amount of hunter harvest demand, with Zarembo receiving more deer harvest demand than any other WAA in the project area. In sum, the DEIS concludes that "[t]he alternatives would further reduce the theoretical deer density, thus increasing the risk that a severe winter would cause declines in the deer population."[291] Despite these harms, the DEIS fails to explain how different project alternatives, designs or actions may promote compliance with the critical deer habitat capability standard.

In regard to road density, the DEIS notes that, according to the Wolf Habitat Management Program and Forest-wide Standards and Guidelines, a total road density of 0.7 to 1.0 mile per square mile or less is recommended to reduce harvest-related mortality risk where locally unsustainable wolf mortality has been identified. Similarly, the DEIS notes that "[i]n order to maintain viable, well-distributed wolf populations, the VPOP committee recommended that road densities should be held below 1.0 mi/mi2 in any three contiguous WAAs."[292] The DEIS then reports that 3 of the 13 WAAs in the Project Area on NFS lands below 1,200 feet in elevation with proposed new road construction have road densities below 0.7 mi/mi2, and the Project would push 2 of them above the 0.7 mi/mi2 thresholds. When all land ownerships below 1,200 feet are considered, 4 WAAs have road densities below 0.7 mi/mi2, and the Project would push 3 of them above the threshold. When considering the 1.0 mi/mi2 threshold, 8 WAAs in the Project Area with proposed road construction have road densities below 1.0 mi/mi2 on all land ownerships below 1,200 feet, but the Project would reduce that number to just 5. As a result, the DEIS concludes that "[r]oad density would increase the risk of overharvest of wolves in certain WAAs. The risk would likely be greatest in WAAs near communities, on western Kupreanof Island, Mitkof Island, and Wrangell Island."[293] Similar to the logging impacts analysis, the DEIS fails to explain how different project alternatives, designs or actions may promote compliance with the important road density standard, nor does it propose or consider a reasonable alternative that would bar road construction in those areas where the road density is above or would lead to the exceedance of the 0.7 mi/mi2 threshold.

Furthermore, the DEIS's road density analysis is deficient because it does not appear to factor in the 128 miles of routes to be designated as open to OHV use, even though OHV routes are used for hunting. The DEIS highlights that OHV trails are often used for hunting: "OHV use has grown in popularity especially in association with subsistence hunting" and "OHV owners from Wrangell transport OHVs to Zarembo and Etolin Islands to ride the road systems and OHV trails, often in search of deer."[294] Yet the DEIS fails to consider how the Alexander Archipelago

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[290] *Id.* at 141.
[291] *Id*. at 146.
[292] *Id.* at 139.
[293] *Id.* at 149.
[294] DEIS at 274.

wolf will be impacted by the increased hunting and trapping pressure that will result from the significant increase in lands open and adjacent to OHV routes.

Despite these substantial impacts to wolves from logging and road-building, which do not factor in harms to wolf dens, the DEIS vaguely concludes that the Project's impacts would be "moderate" without providing a rational explanation connecting the determination to the evidence: "because of the combined reductions of important deer habitat and theoretical deer density, as well as increases in road density in certain WAAs that could amplify wolf harvest in certain areas, the determination is that the effects to wolves (management indicator species) from Alternatives 2 and 3 would be moderate."[295] As such, the Forest Service impermissibly fails to explain whether/why wolves will remain sustainable in Game Management Unit 3 given the additional loss of habitat and prey due to logging and the increases in wolf mortality due to road-building. The Forest Service fails to explain whether (or why) sufficient old-growth habitat (and deer) will remain in GMU 3 to support sustainable wolf populations as the 2016 Amended Forest Plan contemplates. For similar reasons, the Forest Service reaches an arbitrary conclusion that it can approve the Central Tongass Logging Project and still meet NFMA's substantive obligation to manage habitat in such a way as to ensure that wolves remain well-distributed and viable on the Tongass.

XIV. THE FOREST SERVICE MUST INCLUDE AN ALTERNATIVE THAT IMPLEMENTS THE BIOLOGICALLY- PREFERRED OLD GROWTH RESERVES IN THE PROJECT AREA.

Appendix K of the Tongass Forest Plan addresses the process for modifying Old Growth Reserve (OGR) boundaries to conform to Forest Plan criteria as part of project-level reviews.[296] The Forest Service has completely failed to follow this process despite clear evidence in the planning record that numerous OGRs in the very large planning area do not meet Forest Plan OGR criteria. The Forest Service simply notes that OGRs in the project area have been reviewed at various other times and, without disclosing whether the OGRs in the project area currently comply with Forest Plan criteria, states that "it was decided that OGR review was not needed for this project."[297] This decision is arbitrary and contrary evidence before the agency.

In fact, the DEIS language was cut-and-pasted from the Wildlife Resource Report, with the ensuing text omitted.[298] That omitted text and Table 17 identifies 21 VCUs with OGRs that the agency biologists who prepared the WRR recommended for interdisciplinary team review. The reasons for these recommended reviews are usually because the existing OGRs are of inadequate size or composition and need to be modified in order to comply with Forest Plan criteria for small, medium and large OGRs. One VCU, #4490 on Mitkof Island, contains no OGR at all. Another, #4520 also on Mitkof Island, should include important deer winter habitat but does not.

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[295] *Id.* at 149.
[296] 2016 Tongass Plan Amendment, Appendix K, at K-2.
[297] DEIS at 110.
[298] WRR at 28-29.

There are many instances noted where biologically recommended OGRs were not adopted and Appendix K requires consideration of the best biological location for the OGR.[299]

The size, composition and spacing of OGRs are a critical element of the conservation strategy designed to ensure viable, well-distributed populations of wildlife on the Tongass.[300] The Forest Plan provides that project-level reviews will "ensure" that OGR criteria are met in the project area, or at least that any failure to meet that criteria is identified and explained in the NEPA process. These reviews ground-truth the areas labeled as OGRs on maps and ensure that the old-growth habitat conservation strategy is not a fictional paper exercise.

It is also critical to examine OGRs at the project level with regard to their ability to support specific species in the project area. For example, the conservation strategy assumes that large OGRs can support 25 female marten, an amount assumed sufficient to support viable populations in concert with matrix standards and guidelines and other Forest Plan components. But that may or may not be the case in a given large OGR, especially one that in fact does not meet Forest Plan criteria for large OGRs. In such a case, the biologically-preferred OGR could be configured to meet Forest Plan criteria in the way best suited to benefit, for example, marten.[301]

Despite the identification of 21 OGRs that do not meet Forest Plan criteria or otherwise are not currently in their biologically-preferred configuration, the DEIS dismisses the entire subject as unnecessary to address. The final EIS for this project must, at a minimum, include the biologically-recommended OGRs as an alternative. If the Forest Service does not select this alternative, it must explain why.

XV. THE FOREST SERVICE FAILS TO COMPLY WITH NFMA AND NEPA IN PROPOSING TO AMEND THE FOREST PLAN'S SCENIC INTEGRITY OBJECTIVES.

The DEIS includes a proposal for the Forest Service to amend the Forest Plan to downgrade scenic integrity objectives drastically to permit clearcutting on over 10,000 acres on lands which TLMP currently allocates to protect undisturbed scenery. In proposing and analyzing this amendment, the Tongass National Forest fails to comply with NFMA regulations.

In describing the amendment generally, the DEIS states:

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[299] *Id*; 2016 Forest Plan, Appendix K at K-2.

[300] *See, e.g.*, 1997 Tongass Forest Plan Appendix D; 2016 Forest Plan Amendment Record of Decision at 19-25.

[301] Indeed, travel corridors may need to be wider than the minimum suggested under the Forest Plan to effectively promote marten dispersal. Flynn, et al., Abundance, Prey Availability and Diets of American Martens: Implications for the Design of Old-Growth Reserves in Southeast Alaska (December 2004) at v (CTAR 832_0743). Proximity to salmon streams would be another important consideration for a project-level adjustment of OGR boundaries. *Id*.

> a project-specific Forest Plan amendment is proposed and analyzed in both action alternatives to allow less restrictive Scenic Integrity Objectives (SIOs) in selected portions of four of ten timber analysis areas (TAAs) . . . .[302]

In describing the amendment in greater detail, the DEIS states:

> There is a proposed 2016 Forest Plan amendment that would allow the SIOs of certain areas of old-growth harvest to be lowered during the implementation phase to provide for a positive timber sale offer. As planning becomes site-specific, the scenic effects will be more easily assessed, and where proposed harvest opening sizes are not compatible with the current plan, the areas' SIOs may be selectively lowered as needed to provide for a positive timber sale offering.
>
> For analysis, it is assumed that all areas would be lowered from their current SIO to Very Low SIO. During implementation, it may end up that some areas are lowered to Moderate or Low SIO, depending on the implementation plans.[303]

The Forest Service provides no specific language for the amendment for the public to review. The agency fails to provide a map delineating the precise areas where the amendment would have effect. And the agency makes clear that it will not even know where or whether an amendment will be necessary until "planning becomes site-specific," which will occur after approval of the ROD – and the amendment.[304] The location and extent of the amendment "depend[s] on the implementation plans.[305]

The DEIS alleges that the proposed amendment will permit more economic, logging. "The proposed 2016 Forest Plan amendment would allow for greater opportunities to provide positive timber sales by reducing any constraints that scenery may have on the unit design and layout."[306]

This "amendment" fails to comply with NFMA's planning in numerous respects.

For example, the planning regulations require that the agency must "[b]ase an amendment on a preliminary identification of the need to change the plan [that] may be based on a new assessment; a monitoring report; or other documentation of new information, changed conditions, or changed circumstances."[307] The agency provides only a single basis for downgrading scenic integrity objectives over more than ten thousand acres: to reduce the potential for deficit appraised timber sales. The Forest Service cites no new assessment, monitoring or other new information; deficit appraisals for timber sales are not a "changed

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[302] DEIS at 19.
[303] DEIS at 294.
[304] *Id*.
[305] *Id*.
[306] DEIS at 290. *See also id*. at 69-70 (describing impact of scenic integrity objectives on timber volume).
[307] 36 C.F.R. § 219.13(b)(1).

condition" or "changed circumstance" on the Tongass.[308] In fact, the Forest Service was well aware, when it adopted SIOs that provide direction and objectives for landscapes that the objectives would restrict logging to protect the scenic integrity of particular areas.. Because the DEIS fails to provide any valid basis for the proposed plan amendment, the agency must withdraw it.

In addition, the Forest Service has failed to comply with the planning regulations public involvement and notification requirements because the amendment itself is an undefined, moving target. NFMA's regulations mandate that in developing plan amendments, the Forest Service must "provide opportunities to the public for participating in the assessment process" and "engage the public."[309] The Forest Service cannot do so effectively because it has failed to: (1) provide the public with the text of any amendment; (2) disclose where, exactly, the amendment will apply; and (3) disclose the effects of those changes on an area's scenic integrity level.

We note that other forests have understood compliance with the planning regulations to require the agency to provide specific text for a proposed amendment, which enables the public to effectively understand the amendment and provide effective input.[310] This DEIS fails to do so.

The DEIS defines broad areas where the amendment may apply (four TAAs), but within those tens and hundreds of thousands of acres, it fails to provide any information as to where, precisely, clearcuts may occur to violate existing standards. Indeed, it is hard to imagine an impact that depends more on the location than scenery. Scenic impacts may vary depending on where they can be viewed from, whether they constitute foreground, middle-ground or background, whether terrain may obscure impacts, etc. As noted above, the Forest Service admits that it will not know where the amendment will apply until after the agency approves the amendment. The DEIS states: "*As planning becomes site-specific*," that is after the ROD is signed, "the scenic effects will be more easily assessed, and where proposed harvest opening sizes are not compatible with the current plan, the areas' SIOs *may be* selectively lowered *as needed* to provide for a positive timber sale offering."[311] Not only does this approach – approving the amendment first, and defining it later – put the cart before the horse, it makes it impossible for the public to provide meaningful input. For example, planning regulations mandate that the Forest Service shall seek out "Native knowledge [and] indigenous ecological knowledge."[312] The agency cannot seek out and engage tribes without knowing the location or impacts of its proposal. The ill-defined nature of the amendment renders public input fruitless.

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[308] DEIS at 295 (plan amendment lowering scenic integrity objectives would "increase the capacity of the entire project area while providing for a positive timber sale offer.").
[309] 36 C.F.R. § 219.4(a).
[310] *See, e.g.*, Lincoln National Forest, South Sacramento Restoration Project (2019) at Appendix A, available at https://www.fs.usda.gov/nfs/11558/www/nepa/106117_FSPLT3_4623831.pdf (last viewed Sep. 16, 2019).
[311] DEIS at 294 (emphasis added).
[312] 36 C.F.R. § 219.4(a)(3).

The DEIS makes clear the agency's failure to define the location of the clearcuts makes it impossible for the Forest Service to know whether it could, in fact, design a project that yields the desired 150 million board feet of old growth and 80 million feet of young growth without amending the plan. Concerning young growth logging, the DEIS states that harvest in areas where the existing scenic integrity equals the scenic integrity standard required in the plan "would need to be carefully sited and designed in order to maintain the existing scenic integrity of the area, and compliance with the SIO [Scenic Integrity Objectives] *may be difficult* to achieve."[313] It is this careful siting and design that needs to happen *before* the "project-specific" NEPA analysis and ROD are complete, not after. The Forest Service needs to complete the required NEPA analysis before it can reasonably decide where and whether a project-specific Plan amendment is appropriate.

Similarly, "[i]mplementation of even-aged management [on old growth stands] will *likely be difficult* in the implementation phase with almost 60 percent of the 9,000 acres needing to be [logged] from areas where the [existing scenic integrity] equal[s] to the [scenic integrity objective]."[314]. The agency concludes that the "existing condition of the project area is *unlikely* to be able to absorb visible effects of the proposed old-growth and young-growth [logging] of Alternative 2 while complying with the current 2016 Forest Service Standards and Guidelines."[315] But "unlikely" and "difficult" do not mean "impossible." Unfortunately, the agency completely fails to evaluate the effects of silvicultural prescriptions other than clearcutting, including two-aged or uneven-aged management (Scene2.III.). The Forest Service must first determine, with careful siting and an appropriate silvicultural objective, whether and how it could meet the Forest Plan rather than changing the plan to ignore existing standards.

The Forest Service's failure to identify where clearcutting will occur, or the potential to mitigate those effects by using silvicultural prescriptions other than clearcutting, and to what extent the current plan could be complied with while still allowing logging, violates NEPA as well. The DEIS fails to analyze in detail an alternative that would require compliance with the existing plan, including careful siting and alternative silvicultural prescriptions to ensure SIOs are met. It appears that tens of millions of board feet could still be logged under this alternative, making it distinct from the no action alternative, as well as capable of meeting at least some of the purposes of the proposal.[316] The Forest Service must either consider such an alternative or explain why it cannot.

The DEIS also fails to comply with NFMA's planning regulations because it does not accurately "[d]etermine which specific substantive requirement(s) within §§ 219.8 through 219.11 are directly related to the plan direction being added, modified, or removed by the amendment and

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[313] Draft EIS at 293 (emphasis added).
[314] *Id*. (emphasis added).
[315] *Id*. (emphasis added).
[316] DEIS at 70 ("an estimated 60 MMBF could be harvested given the assumptions for partial harvest" and applying the existing SIOs). The DEIS does not explain why the Forest Service reaches this number when the DEIS leaves the door open for careful siting to allow more clearcutting.

apply such requirement(s) within the scope and scale of the amendment."[317] The DEIS recognizes the application of this provision, stating:

> If the Responsible Official selects this Forest Plan amendment as part of the Selected Alternative, he will identify which substantive requirements of the 2012 Planning Rule are likely related to a proposed land management plan amendment, as required by the Rule (36 CFR § 219.13(b)(2)). At this time, he believes the following requirements of the Rule will apply: 36 CFR § 219.8(b)(2); 36 CFR § 219.10(a)(1); and 36 CFR § 219.10(b)(1)(i).[318]

We agree that 36 C.F.R. § 219.8(b)(2) applies. It requires that the Forest Plan and amendments thereto "include plan components, including standards or guidelines, to guide the plan area's contribution to social and economic sustainability, taking into account . . . scenic character."[319] However, the proposed plan amendment will allow the destruction of scenic character, without explanation or analysis as to how such character could be protected, and ignoring the social and economic benefits (through cruise ship, small boat tours, and other tourism that rely on the area's scenic beauty) that protection of viewsheds provide. Section 219.10(a)(1) requires that in developing plan and amendment components, the Forest Service "shall consider . . . [a]esthetic values" and "viewsheds."[320] Again, it is unclear how the agency "considered" those values other than to ignore them in order to clearcut old-growth forest. Section 219.10(b)(1)(i) mandates that a Forest Plan and amendments must include "components, including standards or guidelines, to provide for … scenic character."[321] Here again, the plan amendment provides for a *loss* of scenic character over a timespan beyond the average human lifespan, thereby undermining any claim that the amendment complies with this regulation.[322]

Further, the DEIS fails to acknowledge that additional provisions are "directly related to the plan direction being added, modified, or removed." For example, NFMA provisions require that plans and amendments include components that ensure "[logging] would be carried out in a manner consistent with the protection of . . . aesthetic resources."[323] The DEIS fails to explain how gutting scenic integrity objectives over thousands of acres through plan amendment will be "consistent with the protection" of scenic values, and we do not believe that the Forest Service can do so. Any subsequently prepared NEPA document must explicitly address this provision. Because the Forest Service has failed to do so thus far, its analysis violates both NFMA and NEPA.

Forest Service planning regulations also mandate that plans and amendments contain components to "maintain or restore the ecological integrity of terrestrial and aquatic ecosystems

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[317] 36 C.F.R. § 219.13(b)(5).
[318] DEIS at 7.
[319] 36 C.F.R. § 219.8(b)(2).
[320] 36 C.F.R. § 219.10(a)(1).
[321] 36 C.F.R. § 219.10(b)(1)(i).
[322] DEIS at 295 ("the changes in scenic integrity will last … up to approximately 60 to100 years.").
[323] 36 C.F.R. § 219.10(d)(3).

and watersheds in the plan area."[324] By amending the scenic integrity standards, the plan amendment will directly permit the destruction of thousands of acres of old growth forest, which the DEIS admits will degrade habitat for marten, wolves and other wildlife, as discussed in Section XIII, above.

Further, planning regulations mandate that in developing plans and amendments, the Forest Service "shall consider … [r]easonably foreseeable risks to … economic sustainability."[325] Yet the DEIS contains virtually no disclosure of the impact of thousands of acres of massive clearcuts on the millions of visitors who visit southeast Alaska each year to view wild, not degraded, forests. Failure to disclose the reasonably foreseeable impacts from degrading viewsheds with clearcuts violates NEPA's hard look requirement as well, especially given the wealth of information demonstrating that tourism and scenery viewing are much more important economically than timber to Southeast Alaska's economy.[326]

What little analysis the DEIS contains concerning impacts to the tour boat industry is fragmentary and poorly explained. The DEIS downplays the impacts on this industry in a table that shows that the action alternatives will result in only a few hundred "acres with high Scenic Integrity Objectives modified at popular tourist destinations and along high profile excursion routes on the Tongass with the project area."[327] The DEIS provides specific numbers for both Alternative 2 and Alternative 3, disclosing for example that "0 Acres of Foreground Views, 304 Acres of Middleground Views [with an] Avg patch size between 2-12 acres" will be so modified.[328] These are oddly specific numbers given that the DEIS, as described above, states that it has yet to identify where the logging units will be. At the same time, the DEIS provides no explanation for how the agency defined key terms at issue in the table, including "popular tourist destinations," and "high profile excursion route[s]." To take the required hard look, the Forest Service must do more than disclose acres impacted at "popular" or "high profile" routes; all tourists on all routes to which these clearcuts are visible are likely to be negatively impacted. It is also unclear why the Forest Service neglects to calculate the acreage of background views that the project will impact. Further, it is unclear what an "average patch size" of 2-12 acres means. Could there be a couple of 100-acre clearcuts, and numerous 1-acre cuts? Further, if the Forest Service can define the patch size and precise acreage, it should provide a *map* showing the location of these 304 acres of clearcuts. Finally, given the small amount of acreage involved, the Forest Service should consider an alternative that eliminates all clearcuts that will impact foreground and middle-ground views at popular tourist destinations and alone high profile excursion routes. If the agency fails to do so, it must explain why.

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[324] 36 C.F.R. § 219.8(a)(1).
[325] 36 C.F.R. § 219.10(a)(7).
[326] *See, e.g.*, Rain Coast Data, Southeast Alaska by the Numbers, 2018, at 4 (available at http://www.raincoastdata.com/sites/default/files/Southeast%20Alaska%20by%20the%20numbers%202018%20updated%20Sept%2025.pdf (last viewed Sep. 16, 2019) (showing "visitor industry" accounting for 17% of jobs and 11% of income in Southeast Alaska, while timber and three other industries lumped together represent less than 4% of jobs and income).
[327] DEIS at 31 (Table 5).
[328] *Id*.

CONCLUSION

For the reasons set forth above, we respectfully request that the Forest Service not proceed with the logging aspects of the Central Tongass Project. However, if the agency chooses to proceed, then it must prepare and publish a supplementary DEIS that complies with the agency's legal obligations.

Best Regards,

Buck Lindekugel
Grassroots Attorney
SOUTHEAST ALASKA CONSERVATION COUNCIL
2207 Jordan Ave.
Juneau, AK 99801
(907) 586-6942 x 202
buck@seacc.org

Patrick Lavin Alaska Policy Advisor Defenders of Wildlife 441 W. 5th Ave. Suite 302 Anchorage AK 99507 (907) 276-9410 plavin@defenders.org	Edward B. (Ted) Zukoski Senior Attorney CENTER FOR BIOLOGICAL DIVERSITY 1536 Wynkoop Street, Suite 421 Denver, CO 80202 (303) 641-3149 tzukoski@biologicaldiversity.org
Olivia Glasscock Associate Attorney, Alaska Office EARTHJUSTICE 325 4th Street Juneau, AK 99801 (907) 500-7134 oglasscock@earthjustice.org	Andrew Thoms Executive Director SITKA CONSERVATION SOCIETY Box 6533 Sitka, AK 99835 (907) 747-7509 andrew@sitkawild.org
Osprey Orielle Lake Founder/Exec. Dir. WOMEN'S EARTH AND CLIMATE ACTION NETWORK 20 Sunnyside Ave., A-438 Mill Valley, CA 94941 (415) 772-2104 osprey@wecaninternational.org	Natalie Dawson, Executive Director Audubon Alaska 431 West Seventh Avenue, Suite 101 Anchorage, AK, 99501 907-276-7034 ndawson@audubon.org

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Chapter 3

WHY KEEP AREAS ROAD-FREE? THE IMPORTANCE OF ROADLESS AREAS

Nuria Selva[1], *Adam Switalski*[2], *Stefan Kreft*[3] *and Pierre L. Ibisch*[3]

[1]Institute of Nature Conservation, Polish Academy of Sciences, Krakow, Poland
[2]InRoads Consulting, LLC, Missoula, MT, USA
[3]Centre for Econics and Ecosystem Management, Eberswalde University for Sustainable Development, Eberswalde, Germany

SUMMARY

Roadless and low-traffic areas are typically large, natural or semi-natural areas that have no roads or few roads with low-traffic volume. They are relatively unaffected by roads and subsequent developments, and therefore, represent relatively undisturbed ecosystems, which provide important benefits for biodiversity and human societies. Roadless areas are rapidly becoming rare across the globe due to construction of road networks that serve widely expanding human activity. With a few exceptions, roadless and low-traffic areas are not considered in national or international legislation; and consequently, they have been widely neglected in transport planning.

3.1 Roadless areas contribute significantly to the preservation of biodiversity and ecosystem services.
3.2 Planning of new transport routes should identify existing roadless areas and avoid them.
3.3 Subsequent ('contagious') development effects of road construction should be avoided in roadless and low-traffic areas.
3.4 Unnecessary and ecologically damaging roads should be reclaimed to enlarge roadless areas and restore landscape-level processes.
3.5 It is crucial to systematically evaluate the need for and location of proposed roads and implement the principle of 'no net loss' of unfragmented lands when there is no alternative.

An important question during planning is whether the proposed road is really needed, and if so, where should it be placed. When the dissection of a roadless area is absolutely unavoidable, measures to prevent contagious development should be implemented, as well as compensation measures to restore the same amount of unfragmented habitat.

Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo.
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Companion website: www.wiley.com\go\vanderree\roadecology

INTRODUCTION

With more than 64 million km of roads worldwide (CIA 2013), road networks play a primary role in shaping the environment. Approximately 90% of the world's land surface can be reached within 48 hours of travel by road or rail from the nearest city (Williams 2009). The ecological effects of roads extend far beyond the edge of the road itself; and despite the efforts to minimise road impacts in the past decades, a large portion of the planet is affected by roads (e.g. about one-fifth of the continental United States, Forman 2000). Among the numerous impacts of roads, probably the most important is what we have termed 'contagious' development: roads provide access to previously remote areas, thus opening them up for more roads and developments, and triggering land-use changes, resource extraction and human disturbance (Fig. 2.1, Chapter 51). In this context, the importance of keeping the remaining large unfragmented lands road-free becomes an urgent task.

Roadless and low-traffic areas either have no roads or few roads with low-traffic volumes (see Lesson 3.2 for definitions). They have become a rare element of the landscape; only 3% of the conterminous United States is more than 5 km away from a road (Riitters & Wickham 2003). Consideration of unfragmented lands is typically neglected in road planning and biodiversity conservation. The aims of this chapter are to highlight the value of roadless and low-traffic areas, the need to consider them in sustainable transport planning and the importance of road removal to restore them.

LESSONS

3.1 Roadless areas contribute significantly to the preservation of biodiversity and ecosystem services

Lands without roads have not been altered by road effects such as traffic, noise pollution or wildlife mortality due to collision with vehicles. Roadless areas contain natural and semi-natural habitats with a low level of human disturbance, where wide arrays of ecological processes are preserved. Habitats that are more intact provide greater benefits for biodiversity and human societies than degraded habitats (see reviews in DellaSala and Strittholt (2003) and Selva et al. (2011)).

Roadless areas are biodiversity reservoirs. They are important for wildlife and have the potential to conserve sensitive and endangered species (Loucks et al. 2003). They are crucial for species that move across large tracts of habitat, such as brown bears, wolves or elephants (e.g. Blake et al. 2008). Even large unfragmented areas which have been moderately modified (e.g. for agriculture) can still provide landscape connectivity. Roadless areas are known strongholds for salmonids and other fish species (Quigley & Arbelbide 1997), and a significant refuge for native wildlife and plants (Gelbard & Harrison 2003). They also serve as a barrier against invasive and exotic species, and diseases of wildlife, livestock and humans. For instance, the risk of humans contracting Lyme disease is reduced in larger patches of unfragmented forest, where the diversity of vertebrate hosts is higher (Allan et al. 2003).

Roadless and low-traffic areas perform numerous ecosystem services that are vital for humans. These include the maintenance of healthy soil, clean air and clean and reliable supply of water (DellaSala & Strittholt 2003). While some managers suggest that roads are needed to manage fire and pests, roadless areas are generally characterized by lower fire risk and lower frequency of insect outbreaks than roaded areas (DellaSala & Frost 2001). The social and economic benefits of roadless areas, such as non-motorised outdoor recreation, education and scientific values, are large and well documented (e.g. Loomis & Richardson 2000). As human population increases, the demand for undisturbed land and for wilderness experiences will likewise increase.

Roadless and low-traffic areas are important in the context of climate change (Selva et al. 2011). Undisturbed and mature ecosystems provide buffering capacity, moderate weather extremes (e.g. by retaining water) and help to stabilize local climates (e.g. Norris et al. 2012), thereby protecting against the impacts of storm events, like flooding or landslides. Roadless and low-traffic areas of mature forest and peatland are significant in the sequestration of carbon. Roadless areas accommodate adaptations and range shift responses by plants and animals to climate change by providing important landscape connections and moderating the rate of change of local environmental conditions.

With the current rate of road encroachment, biodiversity crisis and global change processes such as climate change, roadless and low-traffic areas may far exceed roaded areas for their benefits provided to human societies (Selva et al. 2011). Therefore, it seems sensible that sustainable transport policies retain and re-establish unroaded lands in order to conserve biodiversity and maintain the health of ecosystems on which we depend (Textbox 3.1).

3.2 Planning of new transport routes should identify existing roadless areas and avoid them

While roadless and low-traffic areas can be broadly defined as natural and semi-natural areas without roads or with few roads of low-traffic intensity, respectively, there are different legal descriptions and criteria used around the globe to identify them. Although road-free areas and areas with low road density or low traffic volumes are not automatically considered in conservation and transport planning, there are two basic approaches to incorporate roads in spatial planning. The first approach identifies road-free areas of a minimum size (e.g. Wilderness and Inventoried Roadless Areas in the United States) or areas with traffic volume below a specified threshold (e.g. Unfragmented Areas by Traffic in Germany, see Textbox 3.1), and the second approach identifies areas with high conservation status. Under this approach (e.g. Last of the Wild global program or areas of good conservation status in the Chiquitano dry forest, Bolivia), roads and their impacts are combined with other indicators, such as human population density, deforestation or cattle grazing, in order to prioritize areas for biodiversity conservation (Table 3.1).

Roadlessness typically correlates with relatively good conservation status. Therefore, indices that assess the environmental impact of roads by identifying roadless and low-traffic areas should be applied during spatial planning (e.g. SPROADI, Freudenberger et al. 2013). The definition of thresholds to identify such areas, such as the minimum size of roadless areas or the maximum tolerable traffic volume, depends on the landscape context. For example, the dissection of relatively small roadless areas (e.g. Fig. 3.2) is a conservation issue in highly populated regions like central Europe, while large road-free areas are a priority in relatively pristine and unfragmented regions, like the Amazon or Siberia.

Textbox 3.1 Recognition and protection of roadless and low-traffic areas in the world.

Wilderness and roadless area protection in the United States

In the United States, many roadless areas were first protected when the Wilderness Act (1964) was passed. Wilderness was defined as 'an area where the earth and its community of life are untrammeled by man, where man himself is a visitor and does not remain'. Wilderness areas in the United States do not allow permanent improvements or human habitation and were originally required to be larger than 2024 ha (Table 3.1). The National Wilderness Preservation System in the United States has grown to more than 40 million ha today. In 2001, the US Forest Service protected an additional 24 million ha of road-free areas larger than 405 ha under the 'Roadless Conservation Rule'. These inventoried areas are protected from building new roads, although they still allow for motorized use, such as all-terrain vehicles, helicopter logging and other uses that are prohibited in wilderness. Walking trails are common in both Wilderness and Inventoried Roadless Areas.

Low-traffic and unfragmented areas in Europe

Large roadless areas are rare in Europe, and, instead, definitions referring to low-traffic areas have been developed. The concept of unfragmented areas by traffic (UAT) was developed by the German Federal Agency for Nature Conservation as a landscape assessment tool (Table 3.1). The UATs are greater than 10,000 ha and not dissected by roads with more than 1000 vehicles/day, by railway lines (twin-track and single-track electrified lines) or by human settlements, airports or channels. The 2008 inventory identified about 9 million ha of UATs in Germany, of which a quarter are protected under European Directives. The eastern part of Germany contains more UATs than western Germany (Fig. 3.1), which may be illustrative of the different degree of fragmentation between eastern and western Europe.

Global roadless areas

A prototype map of roadless areas in the world was developed in 2012 by Google Earth, the Society for Conservation Biology – Europe Section and Members of the European Parliament (http://earthengine.google.org/). Here, roadless areas were defined by using buffers of different distances (from 1 to 10 km) from the nearest road (including dirt roads), rail or navigable waterway (Table 3.1). This map was presented in 2012 at the Rio + 20 Conference in Brazil and at the eleventh meeting of the Conference of the Parties to the Convention on Biological Diversity in India to demonstrate that roadlessness is the most cost-efficient and effective way to protect biodiversity.

Table 3.1 Examples of initiatives across the world which have identified roadless or low-traffic areas for biodiversity conservation.

Initiative	Framework	Region	Criteria	Indicators	Legal enforcement
Wilderness areas	Wilderness Act, 1964	USA	Size	≥2024 ha	Yes
			Relative naturalness	—	
			Roads	Presence/absence	
Last frontier forests	World Resources Institute, 1997	Global	'Wilderness areas'[a]	Sierra Club's global 'wilderness areas' map	No
			Forest cover[b]	Dominance	
			Size[b]	Ability to support viable populations of large, wide-ranging animals for a century	
			Naturalness of structure and composition: various indicators[b]	Dominance	
Inventoried Roadless Areas	Roadless Conservation Rule, 2001	USA	Size	≥405 ha	Yes
Areas of good conservation status	Chiquitano dry forest conservation and sustainable development plan, 2002	Bolivia	Population/km^2	Five classes ranging from 0–4.4 to ≥95.3	No
			Roads, railways, pipelines	Eight classes ranging from 'principal road' to 'pipeline crossing wet savannah'	
			Navigable rivers and lakes	Presence/absence	
			Deforestation	Two classes: values > and ≤30%	
			Cattle grazing	Four classes ranging from 'semi-intensive cattle-grazing in open and semi-open areas' to 'no cattle grazing'	
			Forest concessions, forests accessible by roads	Presence/absence	
Last of the wild	Wildlife Conservation Society and Center for International Earth Science Information Network, 2002–2005	Global	Size	>500 ha	No
			Population/km^2	10 classes ranging from 0–0.5 to >9.5	
			Railroads	Beyond 2 km buffer	
			Major roads	Beyond 2 and 15 km buffer, respectively	
			Navigable rivers	Beyond 15 km buffer	
			Coastlines	Beyond 15 km buffer	
			Night-time stable lights values[a]	Four classes ranging from 0 to ≥89	
			Urban polygons	Presence/absence	
			Land cover categories	Four classes ranging from 'urban' to 'forests, tundra and deserts'	
Unfragmented areas by traffic (UAT)	German Federal Agency for Nature Conservation, 2008	Germany	Size	10,000 ha	No
			Heavily used roads, railway lines, channels, urban centres	Presence/absence	
			Traffic intensity	<1000 vehicles/day	
Roadless areas	Google Earth and Society for Conservation Biology, 2012	Global	Roads, rails or navigable waterways	Beyond 1 and 10 km buffers, respectively	No

[a]McCloskey and Spalding (1989).
[b]Assessed by qualified expert opinion.

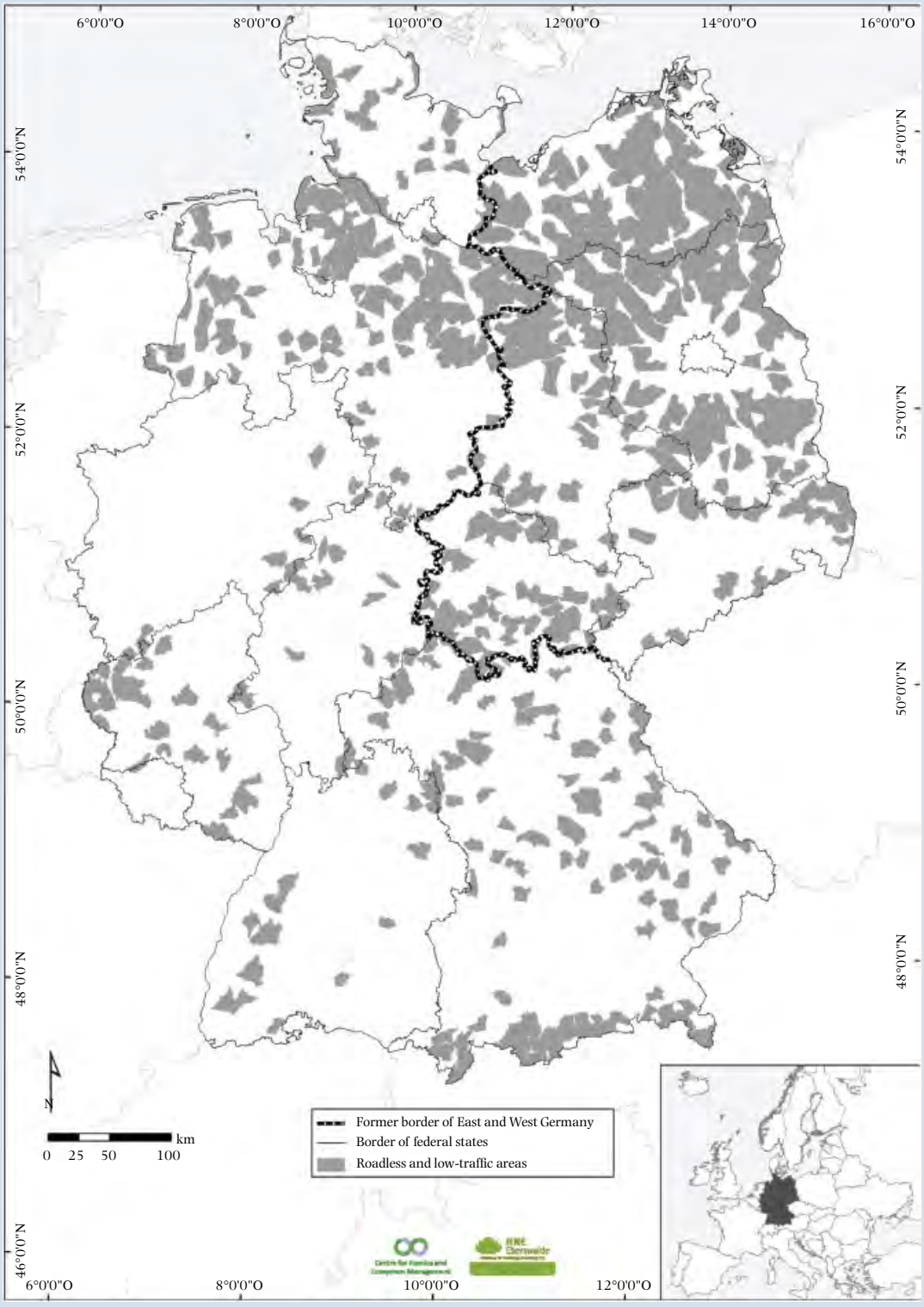

Figure 3.1 Low-traffic areas in Germany (Unfragmented Areas by Traffic, UAT). UATs cover 45% of the new federal states (eastern Germany) versus 18% of the old federal states (western Germany). Source: Adapted from Selva et al. (2011).

Figure 3.2 The Rospuda valley in northeastern Poland (6.3 km^2) is the last pristine percolating fen (or active peatland) of the European temperate zone. Its untouched hydrological system guarantees the stability of the ecosystem (no succession) and the presence of endangered and relict species. In 2007, a road project dissecting this peatland was stopped due to legal infringements of the EU nature directives, after more than 10 years of campaign. The road was finally re-routed through agricultural fields, something that could have been done with proper transport planning years before, thus avoiding high social conflicts and economic costs. Source: Photograph by Piotr Małczewski. Reproduced with permission of Piotr Małczewski.

The roads that cause the greatest environmental damage are those dissecting pristine and unfragmented ecosystems. Even in human-dominated landscapes, the construction of new roads may add additional disturbances to those related to land uses. In this sense, an agricultural landscape without roads still might provide better habitat quality (e.g. connectivity for wildlife) than the same farmland with numerous roads. Given the intensification of land-use pressures across the globe, influencing the patterns of road development to keep roads out of natural areas is the most tractable way to conserve nature (Laurance & Balmford 2013; Laurance et al. 2014; Chapter 2).

3.3 Subsequent ('contagious') development effects of road construction should be avoided in roadless and low-traffic areas

Roads are one of the main drivers of ecosystem change. By facilitating access to previously remote areas, new roads trigger a cascade of land-use changes and habitat degradation (Chapter 51). Roads are almost inevitably followed by urban and agricultural development, and they promote mining, hunting, fishing and logging (Wilkie et al. 2000; Southworth et al. 2011). In Central Africa, logging roads, which represent 38% of all road length, boost unsustainable hunting and the massive loss of wildlife; for example, wildlife densities decreased by 25% 3 weeks after logging roads were opened in Congo (Laporte et al. 2007; Wilkie et al. 2011). The role of roads in deforestation is undisputable and the most rapid rate of forest clearing occurs within 10 km of the road, especially if paved. As demonstrated in the Amazon, greater than 95% of deforestation, fires and atmospheric carbon emissions occur within 50 km of roads (Laurance et al. 2001; Southworth et al. 2011).

Roads also accelerate human migration to the area and subsequent illegal colonization and land speculation (Chapter 51). Road paving, demand for agriculture and cattle ranching areas and ambiguous land tenure systems promote new settlements in undisturbed areas (Southworth et al. 2011). New roads, as well as road improvements in low-traffic areas, have important economic and social impacts, mainly derived from facilitated market access. These collateral or contagious development effects of roads are often more destructive than the direct impacts of the road itself. Sensible transport and land-use planning should carefully regulate contagious development and be supported by appropriate law enforcement (Textbox 3.2).

Textbox 3.2 Roads in developing countries. The case of conservation planning and 'contagious' development in Bolivia.

Road development is often used as an indicator of socioeconomic development. Roads improve mobility of people, but also catalyse the extraction of natural resources and subsequent degradation of ecosystems, and cause profound changes in local socioeconomic systems (Chapter 2).

Bolivia is a socioeconomically poor and biologically rich country that still has a significant portion of its territory covered by natural ecosystems; the latter partly due to a poorly developed road infrastructure (Fig. 3.3, Ibisch & Mérida 2004). However, as in most developing countries, the pressure on ecosystems is increasing rapidly, making the contagious development effect of roads particularly troubling. Whenever new roads provide access to formerly remote areas, people will migrate from other parts of the country and establish (often illegally) new settlements (Chapter 2).

Recent landscape-scale planning in Bolivia used roads as indicators of biodiversity degradation (e.g. Araujo et al. 2010). Roadlessness was taken as a proxy for functional and intact ecosystems and used as a criterion for identifying important areas for conservation. However, the implementation of conservation measures (e.g. land-use planning, including the creation of protected areas) has not been enough to safeguard the high-priority regions. In 2002, an internationally financed road was constructed through the Chiquitano dry forest ecoregion in southeastern Bolivia. A decade later, the indirect impacts of the road (namely forest clearing and expansion of agriculture) have exceeded those outlined in even the most pessimistic environmental impact assessment (S. Reichle, personal communication). The fear that the impacts of new roads cannot be effectively mitigated by accompanying conservation measures has been confirmed. The development and improvement of the road network across Bolivia has continuously accelerated deforestation and other forms of biodiversity degradation. This highlights the importance of keeping unfragmented and natural habitats free of roads as the most effective way to conserve them.

Figure 3.3 Especially in forests, even small and unpaved roads give access for land use such as agriculture or settlement, which may ultimately replace the original ecosystem. Porongo, Santa Cruz, Bolivia. Source: Photograph by Pierre L. Ibisch.

3.4 Unnecessary and ecologically damaging roads should be reclaimed to enlarge roadless areas and restore landscape-level processes

Land managers are restoring roaded areas by closing and reclaiming unneeded or ecologically damaging roads (Fig. 3.4). Many of these roads are historical legacies, but new roads built to support resource extraction should be restored once the activity ceases. There are various treatments possible, ranging from simply blocking the road entrance to full removal and recontouring of the roadbed which allows hydrological and ecological processes and properties to return (Switalski et al. 2004). Increased infiltration and revegetation reduces fine sediment erosion from roads into streams, improving habitat quality for fish and other aquatic species (McCaffery et al. 2007).

Reclaimed roads improve wildlife habitat quality primarily through limitation of motorised access and the restoration of vegetation providing food and shelter for wildlife. Black bears were found to use recontoured roads at much higher rates than roads open to traffic, but also at greater rates than roads closed to traffic with a gate or other barrier (Switalski & Nelson 2011). Similarly, grizzly bears expanded their distribution in Montana, USA, following extensive road reclamation (Summerfield et al. 2004), and moose populations increased following road removal in Nova Scotia, Canada (Crichton et al. 2004). Removing roads at a large scale such as is occurring in the United States has increased the size of core wildlife habitat and has the potential to restore landscape-level connectivity.

Road reclamation efforts and the expansion of roadless areas increase the resilience of ecosystems and help mitigate climate change. For example, as larger storms become more common in the face of climate change, more culverts catastrophically fail during high flows, releasing large amounts of sediment into streams. Removing culverts and restoring stream crossings eliminates this risk and associated negative impacts on aquatic habitats (Chapters 44 and 45). Additionally, when roads are decompacted during reclamation, vegetation and soils can develop more rapidly and sequester large amounts of carbon. Total soil carbon storage increased 6-fold to 65 metric tons C/km (to 25 cm depth) in the northwestern United States compared with untreated abandoned roads (Lloyd et al. 2013). With more than 100,000 km of roads slated for reclamation in the United States alone in the coming decades, road reclamation has the potential to sequester large amounts of carbon.

Figure 3.4 After treatment, vegetation recolonises reclaimed roads reducing erosion and providing food and cover for animals. This photo was taken 10 years after road reclamation on the Clearwater National Forest in the northwestern USA. Source: Photograph by Adam Switalski.

3.5 It is crucial to systematically evaluate the need for and location of proposed roads and implement the principle of 'no-net-loss' of unfragmented lands when there is no alternative

It is important to systematically evaluate whether a road is *really* needed; and if so, explore alternative route options before dissecting and eliminating roadless areas or increasing traffic volumes in low-traffic areas (Fig. 3.5). Infrastructure development and, particularly, road construction should avoid dissecting roadless areas. Road-free areas of natural and semi-natural habitats should be maintained by concentrating traffic on existing highly travelled roads and bundling infrastructure close together (Chapter 5). When this is not possible, it is crucial to protect the remaining area by avoiding contagious development and to apply compensation policies of no net loss to unfragmented lands (Chapter 7). Measures such as road reclamation, promotion of railroads or speed and traffic limitation should also be considered. The implementation of sustainable development schemes at large spatial scales should help prevent the degradation of roadless and low-traffic areas (Fig. 3.5)

CONCLUSIONS

Roadless and low-traffic areas have become scarce, indicating a reduction in well-preserved and functioning ecosystems worldwide. The maintenance of roadless areas is more cost-effective than measures to mitigate or minimise road impacts, or even road reclamation. In this context, a vital task is to identify, map and describe the remaining roadless and low-traffic areas, and to promote their maintenance and protection. Developed countries are removing unnecessary roads and restoring landscape processes to enlarge roadless areas. This exemplifies the need for rewilding in a human-dominated planet. Roadless and low-traffic areas are a timely tool to preserve intact functioning ecosystems at local and global scales in the face of climate change. Their rarity and the services they provide to society call for systematically considering them in modern land-use and road planning.

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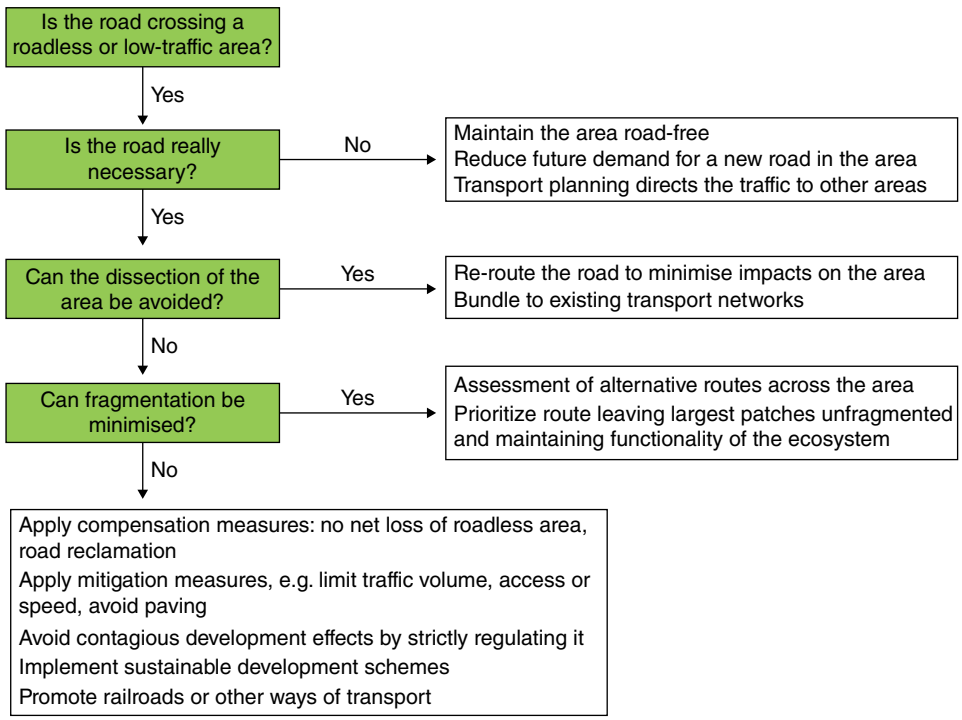

Figure 3.5 Four main questions to ask when planning a road project in roadless or low-traffic areas.

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FURTHER READING

DellaSala and Strittholt (2003): Review of the ecological, social and economic benefits of roadless areas conservation in the USA, with special focus on the conservation assessments of two case studies of roadless areas.

Selva et al. (2011): Identifies the importance of roadless and low-traffic areas for biodiversity conservation and ecosystem services to society, and urges for their inventory and inclusion in urban and transport planning. It includes a legal analysis of roadless areas in Europe and their overlap with the Natura 2000 network, using Germany as a case study.

Switalski et al. (2004): Summary of the current understanding in the science and practice of road reclamation. Taking a multi-disciplinary approach, the article reviews how road reclamation benefits and impacts different natural resources and identifies knowledge gaps.

http://earthengine.google.org/: This is the Google platform for environmental data at a planet scale. It includes a prototype map of global roadless areas.

http://roadlessland.org/: This is an interactive website that shows the inventoried roadless areas in the US and has a number of maps and scientific resources for roadless areas.

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FORUM

Roadless and Low-Traffic Areas as Conservation Targets in Europe

Nuria Selva · Stefan Kreft · Vassiliki Kati · Martin Schluck · Bengt-Gunnar Jonsson · Barbara Mihok · Henryk Okarma · Pierre L. Ibisch

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Abstract With increasing road encroachment, habitat fragmentation by transport infrastructures has been a serious threat for European biodiversity. Areas with no roads or little traffic ("roadless and low-traffic areas") represent relatively undisturbed natural habitats and functioning ecosystems. They provide many benefits for biodiversity and human societies (e.g., landscape connectivity, barrier against pests and invasions, ecosystem services). Roadless and low-traffic areas, with a lower level of anthropogenic disturbances, are of special relevance in Europe because of their rarity and, in the context of climate change, because of their contribution to higher resilience and buffering capacity within landscape ecosystems. An analysis of European legal instruments illustrates that, although most laws aimed at protecting targets which are inherent to fragmentation, like connectivity, ecosystem processes or integrity, roadless areas are widely neglected as a legal target. A case study in Germany underlines this finding. Although the Natura 2000 network covers a significant proportion of the country (16%), Natura 2000 sites are highly fragmented and most low-traffic areas (75%) lie unprotected outside this network. This proportion is even higher for the old Federal States (western Germany), where only 20% of the low-traffic areas are protected. We propose that the few remaining roadless and low-traffic areas in Europe should be an important focus of conservation efforts; they should be urgently inventoried, included more explicitly in the law and accounted for in transport and urban planning. Considering them as complementary conservation targets would represent a concrete step towards the strengthening and adaptation of the Natura 2000 network to climate change.

Keywords Transport policy · Natura 2000 · Fragmentation · Conservation law · Conservation targets · Climate change adaptation

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N. Selva (✉)
Institute of Nature Conservation PAS, Mickiewicza 33, Kraków 31-120, Poland
e-mail: nuriselva@gmail.com

S. Kreft · M. Schluck · P. L. Ibisch
Faculty of Forest and Environment, Eberswalde University for Sustainable Development, Eberswalde, Germany

S. Kreft · M. Schluck · P. L. Ibisch
Centre for Econics and Ecosystem Management, Eberswalde, Germany

V. Kati
Environmental & Natural Resources Management, University of Ioannina, Agrinio, Greece

B.-G. Jonsson
Natural Sciences, Engineering & Mathematics, Mid Sweden University, Sundsvall, Sweden

B. Mihok
Hungarian Natural History Museum, Budapest, Hungary

H. Okarma
Institute of Environmental Sciences, Jagiellonian University, Gronostajowa 7, Kraków 30-387, Poland

Introduction

Habitat fragmentation by transport networks and consequential secondary development has become one of the most serious global threats to biological diversity (EEA 2002; Iuell and others 2003; Laurance and others 2009;

Benítez-López and others 2010). With more than 100 million km of roads worldwide (CIA 2008), the road network plays a main role in shaping the environment. Road effects have been widely studied and include biodiversity decline, environmental degradation, alteration of ecological processes and ecosystem services, and increases in both extinction and outbreak probabilities (Forman and Alexander 1998; Trombulak and Frissell 2000; Forman and others 2003; Fahrig and Rytwinski 2009). By acting as a barrier, roads isolate populations, reduce the overall landscape connectivity and restrict (or even block off) gene flow for a wide variety of taxa (Keller and others 2004; Epps and others 2005; Riley and others 2006; Balkenhol and Waits 2009). In a long term, this loss of genetic diversity and connectivity increases the extinction risk of populations and, reduces their ability to adapt to future global changes. In general, these effects are synergistic, extremely complex, cumulative and time-lagged (Forman and Alexander 1998; Findlay and Bourdages 2000; McGarigal and others 2001; Forman and others 2003).

The spatial influence of these effects ("road-effect zone") ranges from a few meters to kilometres (e.g., Forman and Deblinger 2000). When taking into account this road area-of-influence, about one fifth of the land in USA and the Netherlands is ecologically affected by the road system (Reijnen and others 1995; Forman 2000). Estimates indicate that only 18% of the USA lands are more than 1 km away from the closest road (Riitters and Wickham 2003). Not only major roads, but also minor and unpaved roads may have a considerable impact on the environment (e.g., van Langevelde and others 2009). This may be especially true when crossing natural habitats. Natural areas are being increasingly fragmented by a rapidly expanding transport network, together with urban sprawl (EEA 2006, 2010). In the case of USA forests, estimations yield about 11% of all forest located within 85 m of a road (Riitters and Wickham 2003).

The secondary impacts of roads account for an even more serious threat to biodiversity and ecosystem resilience. Land use and transport networks are interdependent in complex ways (Wilkie and others 2000; EEA 2006; Müller and others 2010). Roads facilitate human access into formerly remote areas, accelerating land use change, habitat degradation and biodiversity loss, due to an increase in hunting, poaching, fishing, tourism, logging, mining, fires and urbanization (Trombulak and Frissell 2000; Wilkie and others 2000; Hawbaker and others 2006). Urban development and sprawl are strongly linked to transport networks, also in rural and natural environments (Wilkie and others 2000; EEA 2006; Müller and others 2010). Thus, the density of transport infrastructures is a good indicator of the intensity of human activities and their impacts on biological diversity, and can be taken as a proxy for general disturbance levels (e.g., Wilkie and others 2000; Sanderson and others 2002; Hawbaker and others 2006; Theobald 2008; Laurance and others 2009). Anthropogenic disturbances, in general, cause stress and reduce resilience and adaptive capacity of populations and species. This is of special concern in the context of climate change, which is increasing local extinction rates and forcing latitudinal and elevational shifts in species ranges (Walther and others 2002; Parmesan 2006).

Europe, as the cradle of industrialization and vehicular transport, is probably the continent most highly fragmented by transport infrastructures. Especially the EU-12 countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Sweden, United Kingdom), historically highly developed and crowded, constitute the epicenter of habitat conversion and fragmentation (Pullin and others 2009). The quality of road data is inconsistent across Europe. It would be informative, for example, to differentiate between urban and rural roads, as well as among road types (motorways, highways, minor roads). However, such specific data are available only regionally or even locally. Taking into account these constraints, the following examples convincingly highlight the issue raised in this paper. The total length of roads belonging to the "Trans-European Transport Network" (TENT-T, a subset of the continent's overall road network targeted to support the economical integration of the EU) in 2005 was 98,500 km, of which 78% corresponded to roads in EU-15 countries (EU-12 plus Greece, Portugal, Spain, data from TINA 2008). In a 10-year period (1995–2005) the length of "motorways" has increased by more than 13,000 km in the EU countries (Steer Davies Gleave 2009). While EU plans imply slight increases of its total length, planned upgradings would increase the proportion of "motorways" in the network from 49% (2005) to 63% (2020). The land dedicated to transport networks continues to increase in the whole EU. In the period 1990–1998 approximately 10 ha of land were taken for new motorway construction every day in the EU-15 (EEA 2002). For example, in the Netherlands, on average 1 km^2 of land is crossed by 3 km of asphalt road (EEA 2002); and the average size of polygons enclosed by the network of all roads is 1.14 km^2 (van Langevelde and others 2009). In Belgium, transport infrastructure already occupies more than 4% of the country's surface area (EEA 2002).

The environmental consequences of this process may be different in the already highly fragmented EU-15 and in the New Member States (accessions from 2004; Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, EU-27) with a lower density of roads and generally harbouring relatively well-preserved biodiversity and ecosystems, but

where transport infrastructures are developing quickly after their accession. Fragmentation by transport infrastructures in Hungary and in the Czech and Slovak Republics are already more severe than the EU-15 average. In the 1990s, total motorway length doubled in the New Members (2300 km built), while in the EU-15 it increased by almost one third (12000 km built, EEA 2002). The average size of contiguous land units not cut through by "major" transport infrastructures in the New Members (174 km^2, EEA 2002, data from 1998) is still above the average of the EU-15 (121 km^2). However, differences between individual EU Member States are more pronounced; Finland, and Scandinavian countries in general, being the least fragmented in the continent, followed by countries in the Carpathian region. Mountainous countries, like Italy or Austria, still maintain relatively large unfragmented patches (EEA 2002).

Thus, it seems reasonable to hypothesize that the few areas of low or no road fragmentation still existing in Europe might be an important focus of future conservation efforts. In this paper, the term "roadless areas" refers to relatively large areas without any roads, whereas areas containing only roads with low-traffic intensity, below an established limit, are termed "low-traffic areas" (see definition below). Our main goal is to bring attention to the conservation value of roadless and low-traffic areas in Europe, specifically in the EU. We aim at (1) describing the benefits of roadless and low-traffic areas for biodiversity conservation; (2) exploring how these areas are valued and considered in European legislation; (3) assessing how low-traffic areas are protected as Natura 2000 sites in Germany, as a case study, comparing the western and eastern parts of the country; and, (4) discussing the potential role of roadless and low-traffic areas to strengthen the effectiveness of the Natura 2000 network, especially in the context of climate change and the unaccomplished goal of halting biodiversity loss by 2010 (EU 2001; EC 2010), as well as their integration into legal instruments and transport policies.

Importance of Roadless and Low-Traffic Areas in Biodiversity Conservation

Roadless areas and, to a lesser extent, low-traffic areas, represent relatively undisturbed natural habitats and functioning ecosystems. As at low traffic intensity, road impacts, such as the barrier effect for fauna, wildlife disturbance or pollution, are dampened (Iuell and others 2003; Jaeger and others 2006; Theobald 2008; Charry and Jones 2009), it is sensible to assume that low-traffic areas may also represent sites of high conservation value, especially in Europe, a human-dominated landscape. Under this scenario, the ecological benefits described for roadless areas, which have been the focus of most research, may well apply to low-traffic areas as well.

Scientific evidence shows that roadless areas are critical in maintaining biodiversity, ecosystem processes, connectivity and overall ecosystem integrity. Large, well-connected patches increase landscape connectivity and complement the network of protected areas (e.g., DeVelice and Martin 2001; Loucks and others 2003; Crist and others 2005). Thus, roadless areas sustain important elements of ecosystem integrity, such as the ability of species to move and natural processes to function. They largely contribute to the preservation of native biodiversity and contain more species and individuals, species with large spatial requirements (e.g., top carnivores), and species sensitive to human disturbance (Haskell 2000; Watkins and others 2003; Angelstam and others 2004; Blake and others 2008; Chen and Roberts 2008). They have the potential to ensure sufficient habitat for viable populations of species of conservation concern, as well as to increase the representation of rare ecological communities (Strittholt and DellaSala 2001; Loucks and others 2003; Crist and others 2005). They serve as a barrier against pests, diseases (of wildlife, livestock and humans, e.g., the Lyme disease) and invasive species (Strittholt and DellaSala 2001; Allan and others 2003; Gelbard and Harrison 2003; Holdsworth and others 2007; von der Lippe and Kowarik 2007). They ensure crop pollination, air quality, water supply and erosion control. It is in these large areas of unfragmented land that ecosystem services, vital for human societies, are rendered (Millennium Ecosystem Assessment 2005).

Roadless and low-traffic areas are of special importance in the context of climate change because they are more resilient than areas more fragmented by roads, and because they have a vast buffering capacity (McGarigal and others 2001). Their ecosystem dynamics are still internally driven, as opposite to the dynamics of fragmented patches, which are predominantly driven by external forces (Saunders and others 1991). Ecosystems already fragmented and stressed by human activities will be more vulnerable to climatic threats, while large intact areas better resist and recover from climate change impacts (Markham 1996; Laurance and Williamson 2001; Noss 2001; Opdam and Wascher 2004; Ferguson and others 2008). These relatively undisturbed habitat patches can facilitate movements of organisms in the case of climate-forced range shifting. In general, they may represent "havens" for many species that are displaced from former habitats (Noss 2001; Lovejoy 2006). By slowing the rates of changes, moderating local climate, and being more diverse and resilient, roadless and low-traffic areas may contribute to mitigate the effects of species phenology changes and trophic

mismatches caused by climate change (Parmesan 2006), and to facilitate species adaptation.

Especially when comprising forest ecosystems or peatlands, roadless and low-traffic areas can play an important role in carbon fixation. Undisturbed habitats may be better players in carbon sequestration than their fragmented and degraded counterparts (Harmon and others 1990; Laurance and Williamson 2001; Ferguson and others 2008; Luyssaert and others 2008). It should be a relevant hypothesis to test that relatively carbon-rich ecosystem types in roadless and low-traffic areas store more carbon for maintaining a less stressed and thus more functional status. In the case of forests, in areas with poor access (e.g., in remote mountain areas), the amount of deadwood and soil carbon should be higher. Roadless and low-traffic areas also provide protection against the impacts of storm events, like flooding or landslides, and wildfires (lower fire risk and higher resilience; USDA Forest Service 2000, 2001; DellaSala and Frost 2001; Laurance and Williamson 2001; Ferguson and others 2008). These relatively intact areas contribute to floodplain protection and drought abatement, as well as to maintain local climates stables and buffering weather extremes. The social and economic benefits of roadless and low-traffic areas, such as recreation, have also been well documented (Noss 1991; Loomis and Richardson 2000; Krieger 2001).

Roadless and Low-Traffic Areas in the European Legislation

Roadless and low-traffic areas, as lands with a relatively low human footprint and good conservation status, have been considered a priority in regional conservation planning in several countries outside Europe. For example, in Bolivia, various conservation planning exercises on regional and national scales followed a functional approach and integrated roadless areas as surrogates for functional conservation targets, such as ecosystem processes and emergent features of biodiversity, especially required in the face of environmental change (viability, resilience and adaptive capacity; Ibisch and others 2005). However, the most ground-breaking initiative and important precedent has been the U.S. *Roadless Area Conservation Rule* of 2001. It stated that 237,000 km^2 within the U.S. National Forest System (2% of US continental land) will remain roadless and protected from most forms of timber extraction. The two inventories of roadless areas, RARE I and RARE II, included unfragmented patches larger than 2024 ha (an important part of which was designated as Wilderness) and 405 ha, respectively (see USDA Forest Service 2001; Strittholt and DellaSala 2001; Turner 2006, 2009 for details).

In Europe, initiatives specifically restricting road development in natural areas and giving special attention to the protection of roadless and low-traffic areas have hardly been launched. The centerpiece of the EU nature conservation policy is the Natura 2000 network, which consists of Special Protection Areas and Special Areas of Conservation delineated according to the provisions of the Birds and Habitats Directives, respectively (79/409/EEC and 92/43/EEC, see Pullin and others 2009). Although both European Directives oblige the Member States to take the appropriate measures to maintain the integrity of Natura 2000 sites and to guarantee the long-term persistence of species and ecosystems, in practice they face enormous difficulties in avoiding habitat fragmentation. Very illustrative are recent conflicts like the planned construction of the Via Baltica express-way through the Biebrza marshes, the unique Rospuda mire and two large natural forests in northeastern Poland (EEA 2006). Moreover, a high proportion of Natura 2000 sites is already in close proximity to major transport infrastructures and/or will be potentially affected by the future development of the European transport network (Fisher and Waliczky 2001; EEA 2002).

We conducted an exploration of European legal instruments, ranging from selected national laws to EU nature conservation directives and European conventions (Table 1, see supplementary material (Appendix) for detailed description of the laws). Only one of the explored laws considered roadless or low-traffic areas as a conservation target, although, paradoxically, the majority of them aimed at protecting other targets which are inherently and intimately related to fragmentation like connectivity, ecosystem processes or integrity. One important finding is an apparent conceptual shift from mere species and habitat protection (e.g., Bern Convention 1979) to more holistic approaches of ecosystem conservation, including processes, functions and aspects of integrity. We especially consider the Carpathian Convention (2003) that explicitly addresses regulations of traffic impacts and development, and encourages the parties to develop sustainable transport policies. Only very recently, Germany established that "traffic and energy infrastructure and similar projects shall be integrated so that fragmentation and consumption of the landscape as well as ecological impairment is avoided or reduced to a minimum" (Federal Nature Conservation Act from 29 July 2009; Table 1). In spite of the apparent trend that European nature legislation is starting to consider minimising fragmentation by transport infrastructures, it is unfortunate that neither the EU nor the large majority of national laws recognise the significance of areas with low levels of fragmentation by roads in their conservation policies.

Table 1 Conservation targets and entities explicitly considered in selected European legal instruments, including Conventions, European Directives and national laws

Country or region	Roadless and low-traffic areas	Ecosystem services	Natural resources	Ecosystem integrity	Ecosystem functioning	Ecological processes	Connectivity	Biodiversity	Landscape	Natural ecosystems	Habitats	Native species (flora&fauna)	Natural heritage
Bern Convention region	–	–	–	–	–	–	–	–	–	–	X	X	–
Alpine Convention region	–	X	X	X	X	X	X	X	X	X	X	X	–
Carpathian Convention region	–	X	X	X	X	X	X	X	X	X	X	X	X
European Union	–	–	X	X	X	–	X	X	X	X	X	X	X
Germany	–	–	X	X	X	–	X	X	X	X	X	X	X
Poland	–	–	X	X	X	–	X	X	X	X	X	X	X
Spain	–	X	X	X	X	X	X	X	X	X	X	X	X
Sweden	–	X	X	X	X	X	X	X	X	X	X	X	X
Hungary	–	X	X	–	–	X	X	X	X	X	X	X	X
Cyprus	–	–	X	–	–	X	–	X	X	X	X	X	X
Greece	–	X	X	–	X	X	–	X	X	X	X	X	X
United Kingdom	–	–	–	–	–	–	–	(–)	(–)	–	X	X	(–)

See Fig. 1 and supplementary material (Appendix) for details of the countries included in each region and the respective laws. Symbol "X" indicates inclusion of targets and symbol "–" indicates exclusion; (–) except Scotland, whose law includes those conservation targets

Roadless and Low-Traffic Areas and Natura 2000: Germany as a Case Study

Germany is one of the largest European countries, located in the center of the continent, including a wide variety of biogeographical regions. It particularly exemplifies different situations in European nature conservation. After World War II, Germany was divided into the Federal Republic of Germany (western Germany) and the German Democratic Republic (eastern Germany); in 1990 they were unified again. Differences in natural conditions, history, political regimes, social models and economic development between eastern and western Germany illustrate well the differences between the so-called "western" and "eastern Europe," once separated by the Iron Curtain. Germany lies in the transition zone between these two parts of Europe (Fig. 1). It reflects somehow different situations between the highly developed and industrialized countries in EU-15 and the New Member States, more rural and less fragmented by transport infrastructures. These two German regions also show strong differences in population density; the "old" Federal States (former Federal Republic of Germany) have almost twice the population density of the "new" Federal States (former German Democratic Republic).

Germany is the first European country where data on the distribution and size of low-traffic areas have become available. The German Federal Agency for Nature Conservation conducted a first inventory of large areas not cut by major transport infrastructures (BfN 2008), whose data were used for the present study (Federal Agency for Nature Conservation, technical data on Natura 2000 from 2008, unpublished). These low-traffic areas were defined as larger than 100 km^2 and not dissected by roads with more than 1000 vehicles per day, by railway lines (twin-track and single-track electrified lines) or by human settlements, airports or channels (with the status of a Category IV Federal waterway or above). These criteria are generally applied in Europe (e.g., Andel and others 2005; Jaeger and others 2007; BfN 2008). Although further research to identify threshold values for traffic volumes are needed, the value of 1000 vehicles per day seems to be an acceptable synthesis of the current ecological evidence and models

Fig. 1 Map of Europe indicating the members of the European Union (with a distinction of the New Member States that have acceded since 2004) and the contracting parties under the Alpine and Carpathian Convention

and may serve as a preliminary basis for further discussions. Below this threshold many, though certainly not all, populations of conservation-relevant species dissected by a road are thought to remain viable by several authors (e.g., Hels and Buchwald 2001; Iuell and others 2003; Seiler 2003, 2005; Jaeger and others 2006; Charry and Jones 2009).

We superimposed the GIS shape files of these low-traffic areas with those of Natura 2000 sites in Germany (merging Special Areas of Conservation and Special Protection Areas, Federal Agency for Nature Conservation, technical data on moderately fragmented areas with low traffic intensity from 2006, unpublished) to analyze their spatial relationship. Particularly, our aim was to determine to what extent low-traffic areas are protected within the Natura 2000 network and to what extent Natura 2000 sites lie outside these areas. As the ecological coherence of the Natura 2000 network is one of the main goals of the Habitats Directive, we were also interested in determining the degree of fragmentation of Natura 2000 sites. For this purpose, we counted the number of spatially isolated subareas each Natura 2000 site is composed of and analyzed the class size distribution of subareas for Special Areas of Conservation and Special Protection Areas separately.

Although the Natura 2000 network covers an important proportion of the country (16%; Table 2; Fig. 2), most low-traffic areas (75%) lie outside the network and thus remain without protection. This proportion is higher for the old Federal States (western Germany), where only one fifth of low-traffic patches are protected. The new Federal States are much less fragmented, and about 45% of its surface consists of low-traffic areas, as against 18% in the old Federal States. They also contain a relatively larger proportion of sites designated as Natura 2000. More than half of the Natura 2000 sites in Germany lie outside low-traffic areas, especially in the old Federal States (72% of the sites; Table 2). Natura 2000 sites are highly fragmented, and often they consist of several subareas, many of which have a very small size. Almost 64% of these subareas classified as Special Areas of Conservation are less than 50 ha (Fig. 3). In the case of the Special Protection Areas these figures are better (27%). In general, Special Areas of Conservation comprise smaller subareas; only 4% of them cover more than 1000 ha, against 26% in the case of Special Protection Areas (Fig. 3).

Discussion: Roadless and Low-Traffic Areas as a Key Element of European Conservation Policy

Biodiversity continues to decline in Europe in spite of considerable conservation efforts carried out by administrations as well as non-governmental organisations (EC 2010). The unaccomplished target of halting biodiversity loss by 2010 (EU 2001; EC 2010) calls for additional conservation measures to be put into practice as soon. Fruit of this concern are recent initiatives of the European Commission on defining targets beyond 2010, developing "Green Infrastructures" or scaling up efforts to protect wilderness (EP 2008, 2009; EC 2011a, b). The need to strengthen the Natura 2000 network and adapt it to the rising challenges of climate change has also been highlighted. In this context, ecosystem resilience and landscape connectivity are key goals that should be reinforced (EP 2010a, b). The MACIS report (Berry and others 2008) states that to prevent and minimise future impacts of climate change on biological diversity in the EU, the minimization of fragmentation and the creation of connectors between protected areas is of extreme importance. Therefore, maintaining unfragmented large patches of natural habitats, i.e., roadless and low-traffic areas, seems a prudent strategy under any climate change scenario.

The capacity of an ecosystem to preserve its integrity and biodiversity increases in large habitats that are well connected and which are far from the influence of external disturbances (e.g., Fahrig and Merriam 1985). We feel that there is enough evidence of the benefits of roadless and low-traffic areas for nature conservation, especially in the context of global change. They represent sites with low human footprint, a high level of ecological integrity, and thus, intact ecosystem functioning and ongoing ecological

Table 2 Representation of low-traffic areas and Natura 2000 sites in Germany, with a distinction between the old and the new Federal States

	Old Federal States	New Federal States	Whole Germany
Surface	248,884	109,025	357,909
Low-traffic areas	45,161 (18%)	48,843 (45%)	94,004 (26%)
Natura 2000 sites	33,662 (14%)	23,753 (22%)	57,415 (16%)
Low-traffic areas not covered by Natura 2000 sites	35,677 (79%)	34,398 (70%)	70,075 (75%)
Natura 2000 sites lying outside low-traffic areas	24,178 (72%)	9,308 (39%)	33,486 (58%)

The surface (km^2) and percentage of low-traffic areas, Natura 2000 sites and their overlap are also indicated. Low-traffic areas are defined as larger than 100 km^2 and crossed only by small roads with less than 1000 vehicles per day (Data from 2007, BfN 2008)

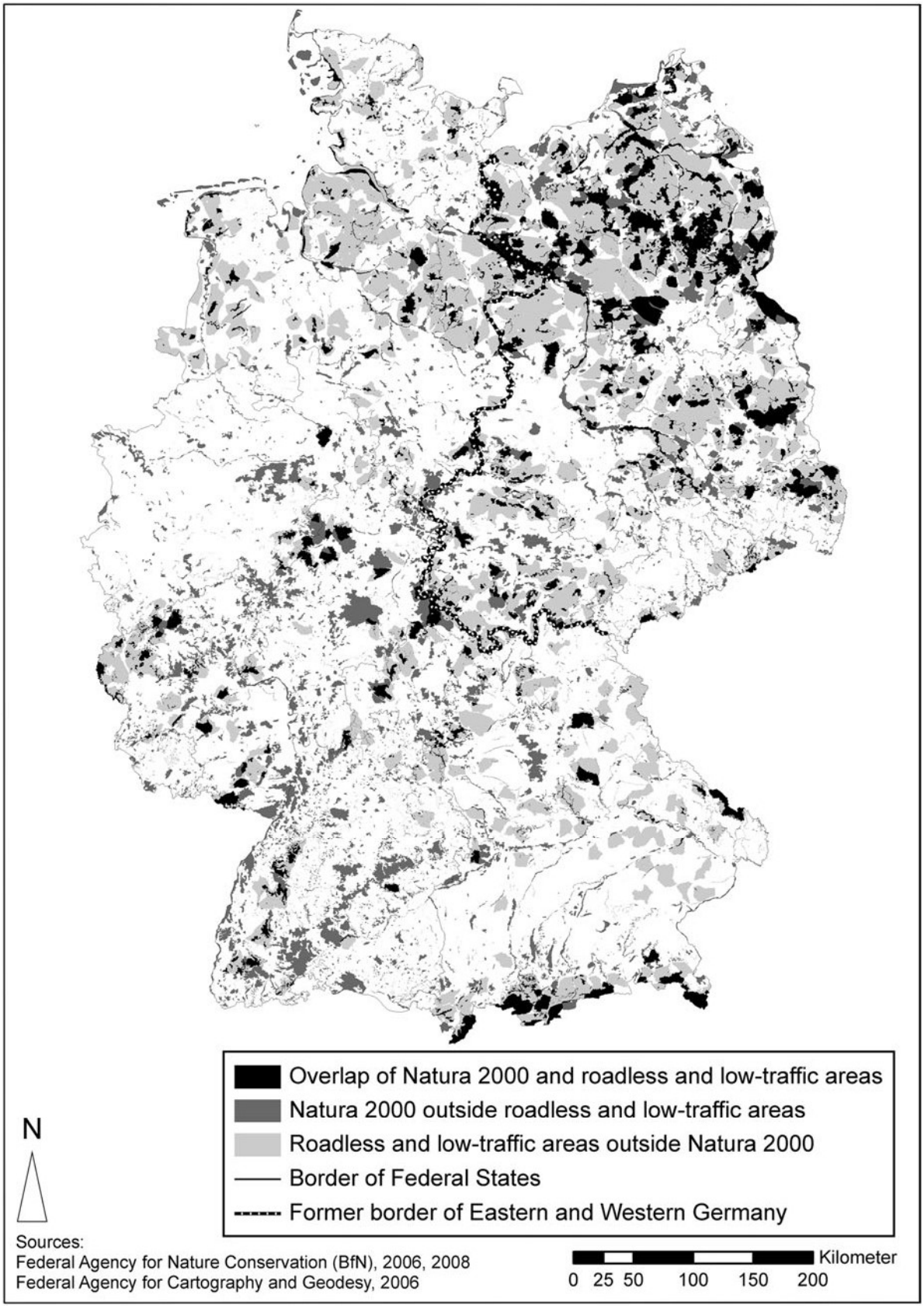

Fig. 2 Natura 2000 network and low-traffic areas coverage in Germany

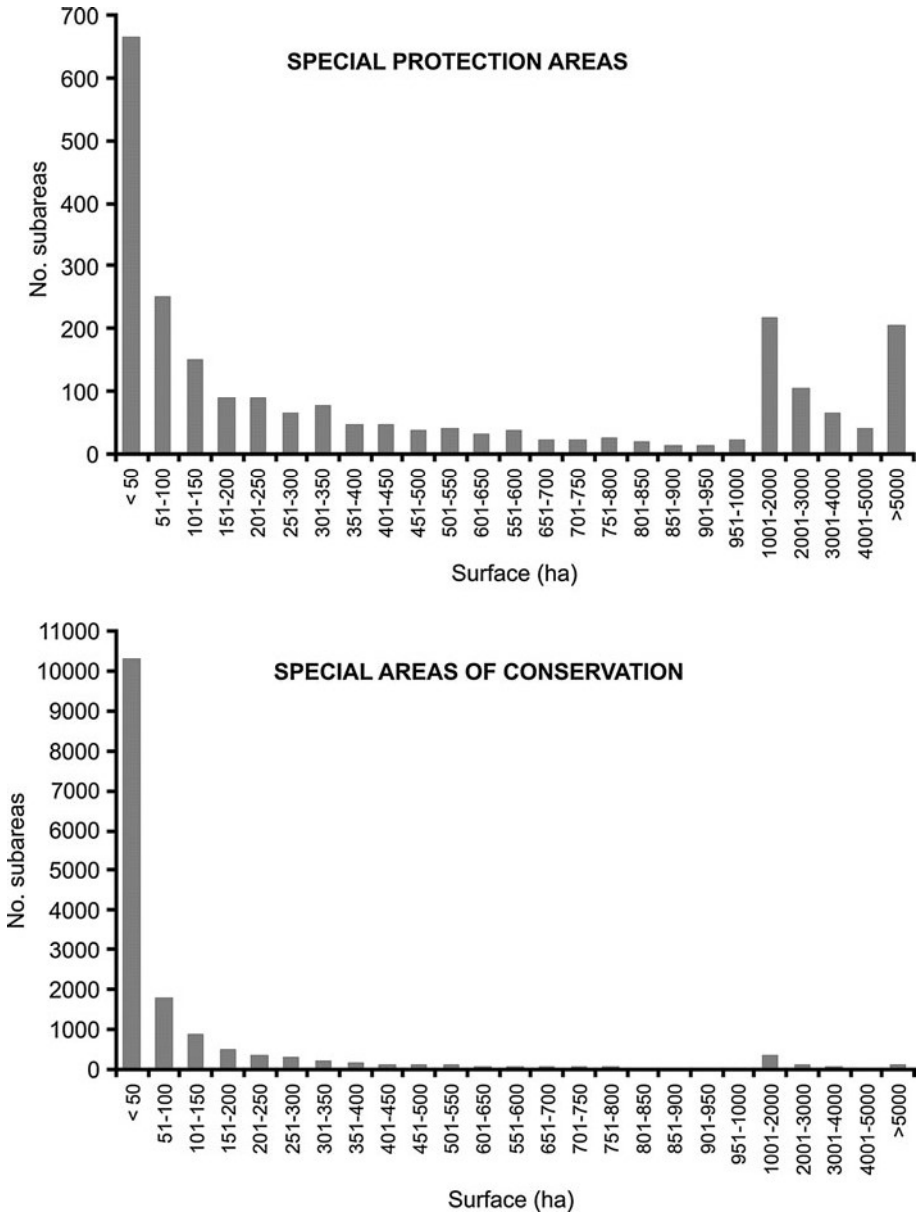

Fig. 3 Size class distribution of the subareas forming Natura 2000 sites in Germany: Special Protection Areas (Birds Directive) and Special Areas of Conservation (Habitats Directive)

processes, which translates into higher resilience and adaptive capacity. Even in densely populated and intensively used landscapes, like Germany, the remaining roadless and low-traffic areas may be of enormous value in supporting resilience and adaptive capacity of the biodiversity. In many areas of Europe, it is probably too late to conserve roadless areas *sensu stricto* to a substantial extent. In this context, the last remnants are of special value, much more if they are primeval or close to a natural state. Although the importance of keeping unfragmented large patches of natural habitats is increasingly recognised (e.g., Jaeger and others 2006; Charry and Jones 2009; Benítez-López and others 2010), more research on the ecological benefits of both roadless and low-traffic areas in Europe is deemed necessary. Such research efforts should be accompanied by improving the quality and availability of road data (e.g., across road types—unpaved roads included—or differentiating between urban and rural roads) and securing data coverage for the entire continent. Conservation policies should focus not only on tangible elements, like species or habitats, but also include surrogates (such as roadless areas) of more abstract conservation targets, like ecosystem functioning, ecological processes or ecosystem services.

The identification and inventory of the roadless and low-traffic areas in Europe should be a top priority. A detailed inventory of these areas, based on sound and concrete criteria, and more detailed estimations of the level of fragmentation by roads in Europe shall form the basis for a proper assessment of the magnitude of the problem. Given

the considerable impacts of minor and unpaved roads in natural ecosystems (e.g., Reed and others 1996; Riitters and Wickham 2003; van Langevelde and others 2009), fragmentation and impact assessments should also consider them. As an example, in Sweden, classically considered as one of the least fragmented countries in Europe (400 km^2 is the average size of non-fragmented land according to EEA 2002), the figures may look quite different when forest roads are taken into account. During the last decade, the rate of road construction in Swedish forests has been approximately 1700 km per year, as a long-term goal of the forestry sector is to have no more than 500 m or 1000 m to the nearest road in southern and northern Sweden, respectively (Swedish Forest Agency 2008). Data on the habitat types covered by roadless and low-traffic areas and their overlap with the Natura 2000 network should be compulsory in Europe. Stronger scientific evidence on traffic and area thresholds following an ecosystem approach is needed; in general, road research needs to effectively address questions of direct management relevance and design studies that have high inferential strength, e.g. evaluating impacts before and after road construction (Gontier and others 2006; Roedenbeck and others 2007).

As a second step, inventoried roadless and low-traffic areas should be considered in European legal instruments in a more explicit way. Fortunately, European legislation has just started to take them into account. In this sense, the recent Carpathian Convention and the German Federal Conservation Act are among the most progressive legal instruments in Europe (see Table 1). The urgent need to protect large, undisturbed habitat patches in Europe is increasingly recognized also at the political level. In February 2009, the European Parliament adopted the Report on Wilderness in Europe (EP 2008, 2009) that calls on the Commission for better protection of wild areas, as a means for climate protection and maintenance of ecosystem services and biodiversity. In this context, a "roadlessness" criterion for the designation of those wild areas in Europe would be highly recommended. Another possible step would be to include roadless and low-traffic areas in the Habitats Directive, either within a new annex of functional targets complementing and facilitating the adaptation of the Natura 2000 network to climate change, or even as a new category of site. Whether a special protection category or designation of these areas is needed or not, large natural areas without roads are protected *de facto*. Mirroring the US legislation, the main goal would be to protect roadless and low-traffic areas from further road development, namely building new roads, increase of traffic volume on existing small roads and use of off-road vehicles. Inclusion of roadless and low-traffic areas in the national and EU Biodiversity Strategies would also be desirable.

Only after being inventoried and receiving a "legal status", roadless and low-traffic areas could be properly integrated into transport and spatial planning. The Environmental Impact Assessment (EIA, 85/337/EEC) and the Strategic Environmental Assessment Directives (SEA, 2001/42/EEC) are essential instruments to assess the impacts from transport infrastructures and for the integration of ecological issues into spatial planning; however the quality of ecological assessments is still limited (e.g., inappropriate criteria and methods, local approach, lack of integration between ecological and landscape assessments, Gontier and others 2006; Joumard and Nicolas 2010). The consideration of biodiversity in environmental assessments requires a holistic approach, i.e., to scale-up to the ecosystem level and to link local and global aspects (Gontier and others 2006; Joumard and Nicolas 2010). A concrete step towards the accomplishment of this vision will be to consider roadless and low-traffic areas in environmental assessments.

Bearing in mind the strong meaning of the term (e.g., Joumard and Nicolas 2010), a sustainable and conservation-sound planning of the European transport network should take into account the still existing roadless and low-traffic areas. Especially in the New Member States, containing highly valuable areas but where transport networks are developing at a brisk pace, more sustainable transport policies are necessary. Research shows that, whenever possible, the design of new routes should avoid dissecting remote and roadless areas (Jaeger and others 2006; Forman 2007; Charry and Jones 2009; Benítez-López and others 2010). Studies on road animal mortality, population persistence and road configuration (Jaeger and others 2006; Charry and Jones 2009) support the "bundling traffic" concept, concluding that (1) the road network should leave areas as large as possible free from disturbances due to traffic, (2) traffic should be concentrated on highly travelled roads, and (3) when traffic cannot be combined on one road, it is better to bundle roads close together than to distribute them evenly across the landscape. Thus, in natural areas with low level of fragmentation and human footprint (e.g., crossed by small roads), the general recommendation is to prevent increases in traffic volume (Charry and Jones 2009).

When avoidance of habitat fragmentation is not possible, mitigation measures and strategies to maintain landscape connectivity, like ecological corridors, should be designed (Iuell and others 2003). Wildlife passages are among the most popular measures to reduce the barrier effect. So far, scientific evidence of their effectiveness from a genetic point of view is still needed (Corlatti and others 2009). In minor roads, traffic calming is another type of intervention used to mitigate negative impacts by reducing traffic volumes and speeds, and which has been shown to increase the persistence on animal populations in areas with a dense road network (van Langevelde and

Jaarsma 2009). Road closure, especially in remote areas, has also been suggested as a measure to decrease fragmentation (Berry and others 2008; Charry and Jones 2009). Integrated solutions are obliged to include urban planning. Given the magnitude of urban sprawl in Europe, also affecting natural habitats (EEA 2006), an equally important goal should be to impede secondary effects along existing roads in roadless and low-traffic areas. This is of high concern in countries lacking spatial plans in most of their surface (e.g., Poland) and where roads are inevitably followed by urban development. The implementation of sustainable development schemes at large spatial scales, linking long and short terms, as well as local and global issues, would prevent the degradation of the integrity of roadless and low-traffic areas and thus, of their contribution to ecosystem and landscape resilience. Clearly, in the preservation of roadless areas and sustainable development of low-traffic areas, synergies of nature conservation and other societal goals are manifold. Just to name a few examples, traffic calming also benefits health and well-being (less accidents, noise and pollution), and water provision to society generally improves in volume and quality with the functionality of roadless and low-traffic areas (e.g., van Langevelde and Jaarsma 2009). Such synergies make roadless areas and low-traffic areas worth considering by a variety of stakeholders beyond the conservation community. With broader societal support, their conservation may considerably gain political momentum.

Roads have brought benefits to human societies for centuries. In the current situation of road encroachment, biodiversity crisis and global and climate change, roadless and low-traffic areas may far exceed roaded areas in the benefits provided. We call for a pan-European conservation strategy defining relatively unfragmented and low- footprint areas ("roadless and low-traffic areas") regardless of their biotic characteristics as conservation targets. Further scientific evidence on their ecological benefits and further research to answer key questions in road ecology regarding low-traffic and roadless areas under the different conditions in European countries is urgently needed. Conservation scientists and administrations should join forces to halt the loss of biodiversity in Europe, to keep healthy and resilient ecosystems and to preserve the services they provide. Preserving the last roadless and low-traffic areas in Europe is a timely post-2010 target.

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RESEARCH ARTICLE

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Description of *Caurinus tlagu*, new species, from Prince of Wales Island, Alaska (Mecoptera, Boreidae, Caurininae)

Derek S. Sikes[1,†], Jill Stockbridge[1,‡]

1 *University of Alaska Museum, 907 Yukon Drive, Fairbanks, AK 99775-6960, USA*

† *urn:lsid:zoobank.org:author:1448D556-54AB-4517-85C0-D76B7070027E*
‡ *urn:lsid:zoobank.org:author:C9282706-20AF-4B9F-A545-36AA3D28204F*

Corresponding author: *Derek S. Sikes* (dssikes@alaska.edu)

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Abstract

A new species of the cryptic, minute, wingless, and enigmatic taxon *Caurinus*, and the second for the subfamily Caurininae, is described from Prince of Wales Island in the Alexander Archipelago, Alaska. It is distinguished from its only congener, *Caurinus dectes* Russell, 1979b, which occurs 1,059 km southeast in Oregon and Washington, based on external morphology and sequences of the mitochondrial gene cytochrome oxidase II. These two species are probably evolutionary relicts – the only known members of a clade dating to the Late Jurassic or older.

Keywords

Caurinus, Boreidae, Mecoptera, taxonomy, Prince of Wales Island, refugium

Introduction

Russell (1979a,b, 1982) described the monotypic subfamily Caurininae, genus and species *Caurinus dectes,* known only from Oregon and Washington, and later described by Beutel et al. (2008) as "arguably one of the most bizarre and cryptic species of Mecoptera and endopterygote insects." Indeed, members of the genus do not key to any order in most keys to insect orders because they lack a produced rostrum, typical of the order Mecoptera, and lack the diagnostic traits that would place them within *any*

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insect order containing flightless adults with rudimentary or vestigial wings. However, they do share with members of the family Boreidae a very distinctive wing morphology and sexual dimorphism in which the adult females are nearly wingless while the males bear shortened scissor-like wings, useless for flight, that bear spines for grasping females during mating. The placement of *Caurinus* within the Mecopteran family Boreidae as the sister taxon to the Boreinae (*Boreus* 26 spp., *Hesperoboreus* 2 spp. [Penny 2013]), is apparently well established based on morphological study (Russell 1979a, b, Beutel et al. 2008, Friedrich et al. 2013) and molecular phylogenetics (Whiting 2002). However, despite recent efforts, the genus remains enigmatic due to its preponderance of plesiomorphic and autapomorphic traits (Beutel et al. 2008). The close relationship of the Mecoptera with the fleas, order Siphonaptera, is of particular evolutionary interest (Grimaldi and Engel 2005, Whiting 2002, Trautwein et al. 2012).

It was therefore with some excitement that we began accumulating *Caurinus* specimens from a large sampling project on the northern end of Prince of Wales Island, Alaska, some 1,059 km from the known range of *Caurinus dectes* Russell. Herein we describe this new species.

Materials and methods

Collections. Specimens will be deposited in the following collections:

CAS California Academy of Sciences, San Francisco, California, USA. (Norm Penny)

MTEC Montana Entomology Collection, Bozeman, Montana, USA. (Michael Ivie)

OSAC Oregon State Arthropod Collection, Oregon State University, Corvallis, Oregon, USA. (David R. Maddison)

PMJ Phyletisches Museum, Jena, Germany (Rolf G. Beutel)

SEMC Snow Entomological Museum, University of Kansas, Lawrence, Kansas, USA. (George Byers)

UAM University of Alaska Museum Insect Collection, University of Alaska, Fairbanks, Alaska, USA. (Derek S. Sikes)

USNM National Museum of Natural History, Washington D.C., USA. (Ollie Flint)

Morphological methods. Images of *Caurinus tlagu* were captured using a Leica DFC425 camera mounted on a Leica MZ16 stereomicroscope in combination with Leica Application Suite © software v.3.8.0. Images were edited using Adobe Photoshop v.7 to remove the background and lighten the images. Observations were made with a Leica MZ16 stereomicroscope (7.1×–115× magnification, 1x planapochromatic objective/10× eyepieces, max resolution 420 Lp/mm, Leica Microsystems (Switzerland) Ltd.). Measurements were made using an ocular micrometer in the MZ16 scope at 50×. Five *C. tlagu* specimens were prepared for scanning electron microscopy (SEM) using a Tousimis Samdri-790 Critical Point Dryer and sputter (gold) coating with a

Ladd coating unit. The scanning electron micrographs were taken with a ISI-SR-50 SEM and the digital imaging program Iridium Digital Imaging System. In addition to the images included herein, many more SEMs and habitat photos are associated with their specimen records via our online database Arctos (http://arctos.database.museum/saved/Caurinus-spp).

Taxon sampling. Two Mecoptera COII sequences from GenBank were used as outgroups: *Boreus westwoodi* Hagen (EU335963.1) and *Boreus hyemalis* (L.) (AF423998.1). *Boreus* species were chosen because they share the family assignment of Boreidae with *Caurinus* and therefore should be more closely related to *Caurinus* than any other genus in GenBank. The single *Caurinus dectes* COII sequence on GenBank (AF424001.1) was initially included (and its existence drove our desire to sequence COII rather than the more common gene COI), but later excluded due to it being suspected of errors (see below). One of the five Alaskan *Caurinus* specimens had ambiguous reads in both directions for its COII sequence, possibly due to co-amplification of a nuclear copy. We excluded this sequence from analysis.

Caurinus dectes specimens were provided by L. Russell. Seven specimens from Lewis County, Washington, collected in 1978 were provided for morphological study and 12 larval and 11 adult specimens from 2012 collections made in Benton and Tillamook Counties, Oregon, for DNA analysis (Table 1). Our collecting efforts on Prince of Wales Island have yielded 37 specimens (18 males, 19 females) of *Caurinus tlagu* (see Collecting methods below, Table 1). Additional, non-type specimens are likely to be found as sampling progresses. These specimens will be archived in UAM and recorded in our online database, Arctos.

DNA sequencing. Adult specimens and larvae designated for DNA extraction were stored at -70°F in cryovials containing 100% EtOH. Specimen data are presented in Table 1. DNA was extracted from whole bodies of five adult specimens from the Alaskan population and from seven whole bodies of the Oregon larvae. During the extraction process, specimens were opened with a pin prick to allow full extraction of DNA from soft tissues. After extraction was complete, specimens were soaked overnight in 70% EtOH to stop further deterioration of specimen exoskeletons in order to preserve them for future morphological study. Extractions were performed using a Qiagen DNeasy© blood and tissue extraction kit which was used according to the spin-column protocol for animal tissues. To amplify the COII gene, the following primer pair was used: forward COII-2a (ATAGAKCWTCYCCHTTAATAGAACA) and reverse COII-9b (GTACTTGCTTTCAGTCATCTWATG) taken from Whiting (2002).

Upon completion, extraction success was tested using a nano-drop spectrophotometer. DNA concentrations were (0.5–4.0 ng/μL). Primers were diluted at a relatively high concentration of 10μM in accordance with Whiting (2002). PCR was performed using the following 25μl PCR-mix: 12.5μl GoTaq DNA polymerase, 1μl each of the forward and reverse primers, 1μl Mg+, 9.75μL DNA-grade distilled water and 1μL template DNA. The following cycling regime was applied: (1) 1 min at 95°C, followed by (2) 35 cycles of 1 min at 95°C, 1 min at 59°C, and 1 min at 72°C, and (3) a final extension of 7 min at 72°C. Amplification success and correct band length was

Table 1. Specimen data (n=50 lots). Also available online at http://arctos.database.museum/saved/Caurinus-spp via Arctos. Geocoordinates are in WGS84 datum. PoW = Prince of Wales Island. * = holotype male *Caurinus tlagu*, with genitalia everted and COII gene sequenced. All other *C. tlagu* specimens are paratypes. W-screen = wet screen, Hab. = habitat. Habitat type codes: T2 = thinned secondary growth, 2= young secondary growth (unthinned), 2o = old (80yr) secondary growth, CC = clearcut, CCe = clearcut / forest ecotone, OG = old growth, AH = alpine heath. Date1 and Date2 = start and stop dates for trap samples.

Catalog Number	Species	State	Locality	Hab.	Method	Date1	Date2	Latitude	Longitude	+/- (m)	sex / stage
UAM:Ento:121022	*C. tlagu*	Alaska	PoW Is. Coffman Cv	T2	pitfall	4/27/10	5/15/10	55.9795	-132.86256	101	male
UAM:Ento:121023	*C. tlagu*	Alaska	PoW Is. Coffman Cv	T2	Berlese	5/13/10		55.9795	-132.86256	101	female
UAM:Ento:135818	*C. tlagu*	Alaska	PoW Is. Coffman Cv	T2	pitfall 4	5/14/10	5/28/10	55.9795	-132.86256	101	male
UAM:Ento:159146	*C. tlagu*	Alaska	PoW Is. Coffman Cv	T2	pitfall 2	7/14/10	7/26/10	55.9795	-132.86256	101	male
UAM:Ento:202339	*C. tlagu*	Alaska	PoW Is. Coffman Cv	T2	pitfall 4	5/18/11	5/31/11	55.9795	-132.86256	101	female , male
UAM:Ento:204005	*C. tlagu*	Alaska	PoW Is. Coffman Cv	T2	Berlese 2	6/14/11		55.9795	-132.86256	101	female , male
UAM:Ento:229946	*C. tlagu*	Alaska	PoW Is. Coffman Cv	T2	pitfall 4	7/27/11	8/7/11	55.9795	-132.86256	101	female
UAM:Ento:229944	*C. tlagu*	Alaska	PoW Is. Hatchery Ck.1	OG	Berlese	8/9/11		55.92444	-132.93938	4	female
UAM:Ento:142985	*C. tlagu*	Alaska	PoW Is. Hatchery Ck.4	OG	pitfall 2	5/14/10	5/30/10	55.88602	-132.8607	11	female
UAM:Ento:142986 *	*C. tlagu*	Alaska	PoW Is. Hatchery Ck.4	T2	pitfall 3	5/30/10	6/14/10	55.88433	-132.89734	26	male
UAM:Ento:204239	*C. tlagu*	Alaska	PoW Is. Hatchery Ck.4	OG	pitfall 2	5/31/11	6/14/11	55.88602	-132.8607	11	male
UAM:Ento:217990	*C. tlagu*	Alaska	PoW Is. Hatchery Ck.4	OG	pitfall 3	6/28/11	7/12/11	55.88602	-132.8607	11	male
UAM:Ento:221708	*C. tlagu*	Alaska	PoW Is. Hatchery Ck.4	2	Berlese 5	7/27/11		55.88285	-132.89795	27	female
UAM:Ento:203237	*C. tlagu*	Alaska	PoW Is. Luck Lk. 1 Rd.	OG	pitfall 4	5/24/11	6/5/11	55.97805	-132.75456	10	female
UAM:Ento:216180	*C. tlagu*	Alaska	PoW Is. Luck Lk. 1 Rd.	OG	pitfall 4	6/21/11	7/6/11	55.97805	-132.75456	10	male
UAM:Ento:154335	*C. tlagu*	Alaska	PoW Is. Luck Lk. 2 Rd.	OG	pitfall 1	7/8/10	7/30/10	55.96855	-132.75615	10	female
UAM:Ento:203238	*C. tlagu*	Alaska	PoW Is. Luck Lk. 2 Rd.	OG	pitfall 3	5/24/11	6/5/11	55.96855	-132.75615	10	male
UAM:Ento:159119	*C. tlagu*	Alaska	PoW Is. Luck Lk. 3 Rd.	OG	Berlese 4	7/29/10		55.95347	-132.7708	5	female
UAM:Ento:203239	*C. tlagu*	Alaska	PoW Is. Luck Lk. 3 Rd.	OG	Berlese 1	6/5/11		55.95347	-132.7708	5	female
UAM:Ento:133943	*C. tlagu*	Alaska	PoW Is. Luck Point	CC	Berlese 2	5/21/10		55.98497	-132.787	25	male
UAM:Ento:159120	*C. tlagu*	Alaska	PoW Is. Luck Point	CC	pitfall 1	7/9/10	8/1/10	55.97953	-132.77156	24	female
UAM:Ento:167053	*C. tlagu*	Alaska	PoW Is. Luck Point	CC	pitfall 1	8/1/10	8/11/10	55.97953	-132.77156	24	male
UAM:Ento:203011	*C. tlagu*	Alaska	PoW Is. Luck Point	T2	pitfall 1	5/23/11	6/5/11	55.98261	-132.77986	6	female
UAM:Ento:229942	*C. tlagu*	Alaska	PoW Is. Luck Point	CC	pitfall 1	8/2/11	8/9/11	55.97953	-132.77156	24	female
UAM:Ento:229943	*C. tlagu*	Alaska	PoW Is. Luck Point	CC	Lindgren	8/2/11	8/9/11	55.97939	-132.77216	25	male

Catalog Number	Species	State	Locality	Hab.	Method	Date1	Date2	Latitude	Longitude	+/- (m)	sex / stage
UAM:Ento:121024	*C. tlagu*	Alaska	PoW Is. Staney Ck.	CCe	pitfall	4/27/10	5/15/10	55.87126	-133.06697	5	male
UAM:Ento:202344	*C. tlagu*	Alaska	PoW Is. Staney Ck.	CC	pitfall 3	5/16/11	5/31/11	55.872	-133.06523	26	male
UAM:Ento:229945	*C. tlagu*	Alaska	PoW Is. Staney Ck.	OG	pitfall 4	7/12/11	7/27/11	55.79901	-133.11782	20	male
UAM:Ento:230091	*C. tlagu*	Alaska	PoW Is. Staney Ck.	OG	pitfall 2	5/14/12	5/28/12	55.79901	-133.11782	20	female
UAM:Ento:231726	*C. tlagu*	Alaska	PoW Is. nr Black Lk	AH	pitfall	7/9/11	7/10/11	55.58818	-132.88881	2	male
UAM:Ento:231727	*C. tlagu*	Alaska	PoW Is. nr Black Lk	AH	pitfall	7/9/11	7/10/11	55.58818	-132.88881	2	female
UAM:Ento:235023	*C. tlagu*	Alaska	PoW Is. Hatchery Ck.4	OG	pitfall	5/15/12	5/28/12	55.88602	-132.8607	11	female
UAM:Ento:235024	*C. tlagu*	Alaska	PoW Is. Luck Point	CC	Berlese	5/31/12		55.98497	-132.787	25	female
UAM:Ento:235025	*C. tlagu*	Alaska	PoW Is. Luck Lk. 1 Rd.	OG	pitfall	5/16/12	5/31/12	55.97805	-132.75456	10	female
UAM:Ento:235026	*C. tlagu*	Alaska	PoW Is. Luck Lk. 3 Rd.	OG	Berlese	5/22/12		55.95347	-132.7708	5	male
UAM:Ento:230088	*C. dectes*	Oregon	Mary's Peak	2o	w-screen Berlese	10/30/12		44.50413	-123.55125	5000	female, male
UAM:Ento:228446	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228447	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228448	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228449	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228450	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228451	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228452	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228453	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228454	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228455	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228456	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228457	*C. dectes*	Oregon	Marys Peak	2o	w-screen	5/11/12		44.50413	-123.55125	5000	larva
UAM:Ento:228458	*C. dectes*	WA	Lewis Co.	2o	Berlese	5/6/78		46.62848	-122.27701	5000	male, female
UAMObs:Ento:228643	*C. dectes*	Oregon	Cape Lookout	2o	w-screen	11/6/12		45.33954	-123.99289	5000	male
UAM:Ento:234931	*C. dectes*	Oregon	Cape Lookout	2o	w-screen	11/6/12		45.33954	-123.99289	5000	male

confirmed visually on an agarose gel stained with ethidium bromide. Bi-directional sequencing was performed at the University of Washington's High Throughput Genomics Unit.

Alignment. Sequences were aligned using CodonCode Aligner v4.0.4 (http://www.codoncode.com/aligner/) and proofread by eye with reference to codon position and the inferred amino acid sequence based on Liu and Beckenbach (1992). Alignment was without difficulty due to the absence of indels within the protein-coding sequence. MacClade was used to produce a consensus of forward and reverse reads (Maddison and Maddison 2005).

Model Selection. JModelTest v2.1.3 (Darriba et al. 2012, Guindon and Gascuel 2003) was used to determine the best fitting model among 88 available for testing. The AIC, BIC and DT all chose the model HKY+G as the best fit for the data.

Analysis. Bayesian analyses were conducted using MrBayes v3.2 (Ronquist and Huelsenbeck 2003) under the HKY+G model with default priors. Two simultaneous MCMC runs with four chains each (3 hot and 1 cold) were performed for 10 million generations and sampled every 1,000 steps discarding a burnin of 25%. To evaluate whether the MCMC analysis had reached stationarity, trace files were examined in Tracer v1.5 (Rambaut and Drummond 2003). These showed signs of good mixing and had plateaued at equal values. The average standard deviation of split frequencies between the two runs had dropped below 0.01 by 12% of the 10M step run, also indicating both runs had converged. Maximum Likelihood analyses were conducted using Garli v.2.0.1019 (Zwickl 2006) under the HKY+G model with 1000 non-parametric bootstrap search replicates in addition to a non-bootstrap analysis of 100 search replicates from random starting trees.

Collecting methods and results. Specimens of this new species were collected primarily using pitfall traps and Berlese funnels (Table 1) as part of our four year, ongoing project investigating forestry practices in the Tongass National Forest (Fig. 1). Two specimens were caught in a very different habitat in pitfall traps set on a transect of 20 traps spaced 100m apart in a treeless alpine zone (917m elevation) near Black lake, Prince of Wales Isl., with tundra-alpine-heath vegetation (e.g. *Harrimanella stelleriana*, *Luetkea pectinata, Rhytidiadelphus loreus*). This collection was part of a rapid biotic assessment of Southeast Alaska alpine zones (Fig. 1A) and was located 45 km southwest of the Coffman Cove collection sites. Pitfall traps consisted of paired (Coffman Cove) or single (alpine) plastic cups 8.3 cm in diameter and 7.5 cm deep filled 1/2–2/3 with non-toxic propylene glycol based antifreeze, Sierra © brand (Coffman Cove), or soapy water (alpine) with rain-roofs ~3 cm from the ground above the traps. Traps were emptied once every two weeks (Coffman Cove) or daily (alpine zone). Paired traps were 30cm apart with a plastic ruler embedded in the ground between them to act as a barrier to divert arthropods into the traps. As part of the Tongass sampling, BioQuip © collapsible Berlese funnels were used with ~ 1m^2 of leaf/moss litter sifted prior to running under 40 watt bulbs for 48h. These methods resulted in 37 specimens collected. However, incredible effort was involved. A total of 1,136 pitfall trap and 284 Berlese samples were processed from 2010 and 2011 that have generated 10,218 beetle speci-

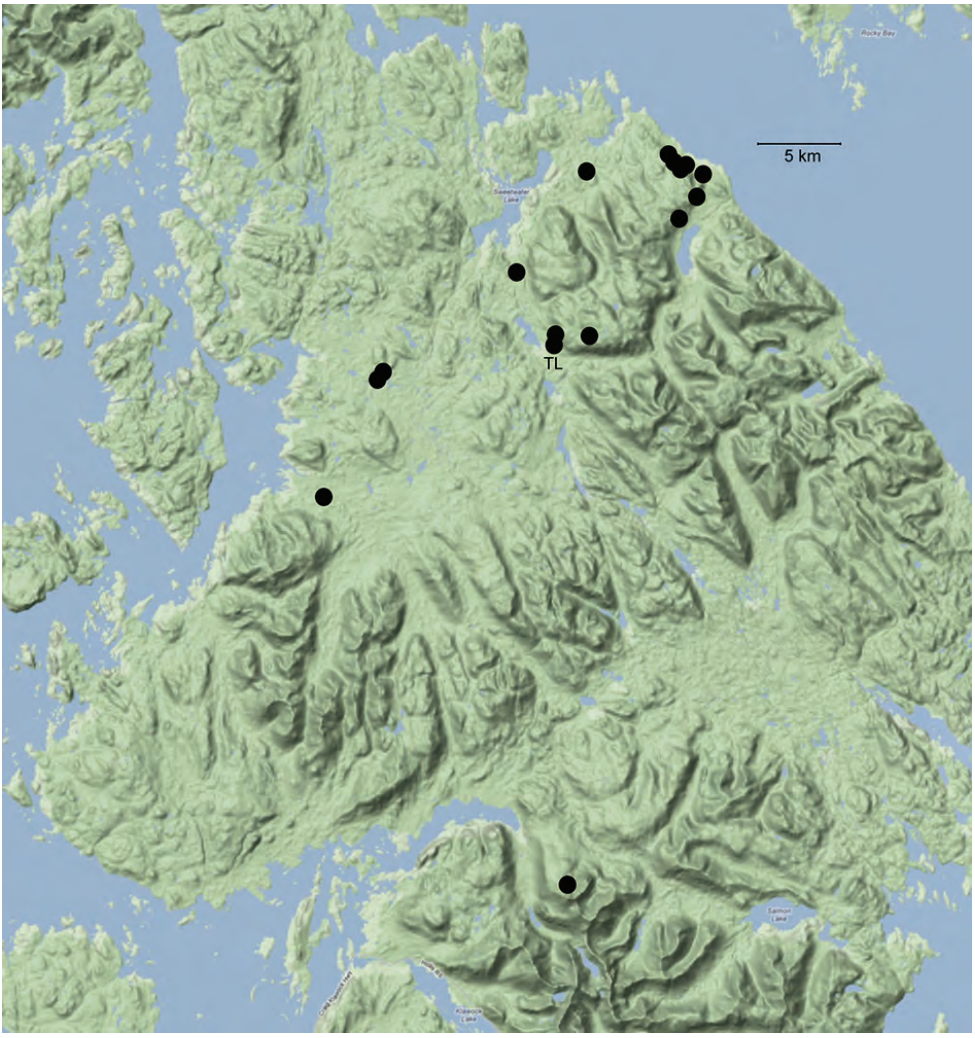

Figure 1. Sixteen sites at which *Caurinus tlagu* specimens were found, north end of Prince of Wales Island, Alaska. Table 1 lists site and specimen data, also available online at http://arctos.database.museum/saved/Caurinus-AK. TL = type locality.

mens to date. The alpine sampling involved 83 pitfall trap samples, which yielded two *Caurinus* specimens. Twenty-six *Caurinus* specimens were captured in pitfall traps, ten in Berlese funnels, and one, surprisingly, in a Lindgren funnel. Great care was taken to ensure pitfall trap rims were at or below the level of the ground – certainly an important factor when trapping an animal ~ 2 mm in size.

The majority of specimens (35/37) were collected in perhumid rainforest dominated by Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), lodgepole pine (*Pinus contorta* var. *contorta*), Alaska yellow cedar (*Chamaecyparis nootkatensis*), red cedar (*Thuja plicata*), and red alder (*Alnus rubra*) (Fig. 2). Of 24 sites sampled in

Figure 2. Habitats of *Caurinus tlagu* **A** Habtiat of type locality, thinned secondary growth with 18 ft. spacing between trees, 55.88433, -132.89734 **B** example of old growth habitat in which specimen UAM:Ento:204239 was found, 55.88602,-132.8607 **C** example of clearcut, a habitat type in which seven specimens were found, 55.872, -133.06523 **D** example of treeless, alpine heath – tundra in which two specimens were found, 55.58818, -132.88881.

the Tongass National Forest project, *Caurinus* was found in 14 sites. Fifteen specimens were found in six of six sampled old growth sites, eleven in three of six sampled thinned secondary growth sites, seven in four of six sampled clear cuts, and one in one of six sampled unthinned secondary growth sites. One additional specimen was found in an ecotone next to a clear cut that was not part of the 24 structured sampling sites. The null hypothesis of *Caurinus* being equally trappable in all four habitat types: old growth, thinned secondary growth, unthinned secondary growth, and clear cuts, (ignoring the ecotone), is rejected ($Chi^2 = 12.59$, df=3, P=0.0056). These animals are less trappable in

unthinned secondary growth sites than expected under the null, and more trappable in old growth and thinned secondary growth sites than expected under the null.

Although boreids are considered winter active insects, our projects were restricted to the summer months. We caught *Caurinus* more or less evenly throughout the period of sampling (mid May – mid August) (Table 1).

Results from molecular analyses

DNA sequence characteristics. The final alignment of the DNA sequences (11 *Caurinus* sequences, 2 outgroup *Boreus* sequences) was 639 base pairs long with 491 constant sites, 21 variable but parsimony-uniformative sites, and 127 parsimony informative sites. Among the *Caurinus* sequences there were 604 constant sites and 35 parsimony informative sites. Of these 35 variable sites between the *Caurinus* species, 34 were binary with all specimens of each species sharing the same base differing from the other species. As expected, most (29) of these variable sites were third codon positions, with six variable first codon position sites, and zero variable second codon position sites. The null hypothesis of homogeneity of base frequencies across taxa was not rejected by a Chi-square test performed in PAUP*4.0b10 (Chi^2=27.5, df=36, P=0.85) (Swofford 2003). These sequences are available from Genbank (accession numbers KF282717 through KF282727) and the aligned NEXUS and tree files are available from TreeBase (http://purl.org/phylo/treebase/phylows/study/TB2:S14415) under study Accession number 14415.

The *Caurinus* species are 98.5% identical in their inferred COII amino acid sequences (209 of 212 amino acids are identical). The three amino acid replacements are as follows: The 113th site of the amino acid translation is an Alanine (nonpolar) shared by all seven *Caurinus dectes* specimens but is a Threonine (polar) in all five *Caurinus tlagu* specimens; at the 114th site an Aspartic acid (acid polar) shared by all seven *Caurinus dectes* specimens is a Asparagine (polar) in all five *Caurinus tlagu* specimens; and at the 148th site an Isoleucine (nonpolar) shared by all seven *Caurinus dectes* specimens is a Valine (nonpolar) in all five *Caurinus tlagu* specimens.

All seven *C. dectes* share identical COII nucleotide sequences whereas only three of the *C. tlagu* share identical sequences, the fourth *C. tlagu* differs at one site (0.156% divergent) from the other three *C. tlagu*. The two *Caurinus* species are 5.44% divergent from each other (uncorrected "p" distance). The two outgroup species are 3.9% divergent from each other, and 21% (*B. hyemalis*) to 20% (*B. westwoodi*) divergent from *Caurinus*. The COII GenBank record of *C. dectes* (AF424001.1) is 21.7% divergent from the seven *C. dectes* we sequenced. Using the parameter values from the Garli analysis (see below) to set the HKY+G model in PAUP*4.0b10 allowed the estimation of distances corrected for multiple hits: the two *Caurinus* species are 7.17% divergent from each other. The two outgroup species are 5.6% divergent from each other, and 106.7% (*B. hyemalis*) to 103.5% (*B. westwoodi*) divergent from *Caurinus*.

Bayesian Analysis. Tracer reported auto-correlation times of 1027 and 1015 for the two runs with Effective Sample Sizes for all parameters of each run above 7000 (with samples from both runs combined, the ESS of each parameter was above 15,000). Parameter estimates of both runs combined were as follows: the harmonic mean of the estimated marginal likelihood was –1515.7, tree length 0.692, the transition/transversion rate ratio (kappa) 6.59, pi(A) 0.356, pi(C) 0.151, pi(G) 0.102, and pi(T) 0.391 with the alpha shape parameter at 0.258.

Garli Analysis. The 1000 bootstrap replicate analysis resulted in similarly strong branch support values as the Bayesian analysis (Fig. 3). One hundred non-bootstrap replicates were completed, the best tree of which was found in 96 of the searches and was identical in topology to the Bayesian tree (Fig. 3) with a -lnL of 1476.75, tree length of 0.858, and parameter values of: K parameter 8.789, ti/tv 3.321, pi(A) 0.3596, pi(C) 0.1481, pi(G) 0.0991, and pi(T) 0.3933 with the alpha shape parameter at 0.1733.

Both the Bayesian and maximum likelihood analyses found strong support for reciprocal monophyly of both *Caurinus* species (Fig. 3).

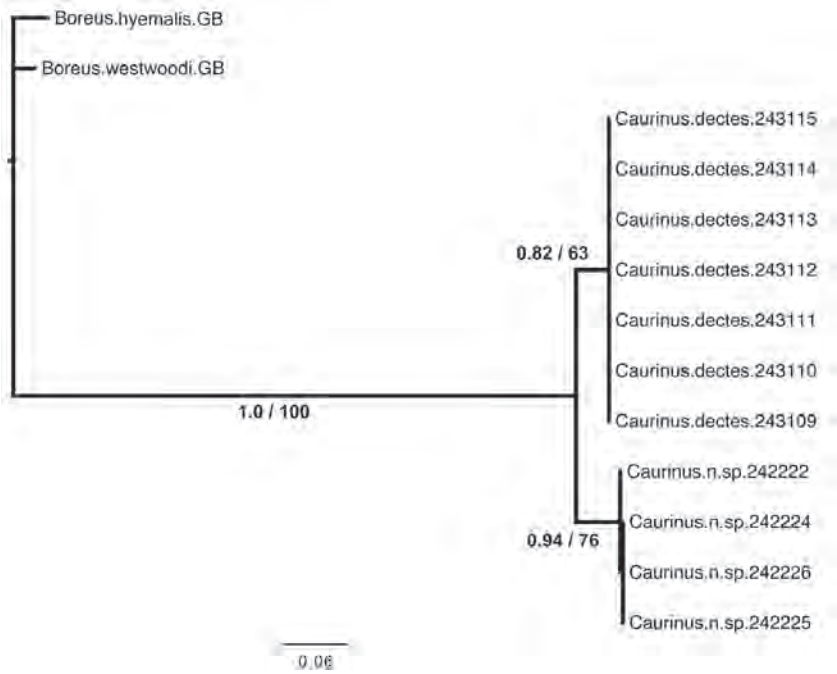

Figure 3. Inferred phylogeny from Bayesian analysis. Each terminal is a single specimen with the UAM cryovial barcode of its DNA extraction indicated by a six digit number. Branch support is indicated as estimated posterior probability from the Bayesian analysis first and maximum-likelihood bootstrap percentages second. Branch lengths are proportional to the number of substitutions per site as reconstructed by MrBayes 3.2. Specimen 242224 is the holotype of *Caurinus tlagu* http://arctos.database.museum/guid/UAM:Ento:142986. The remaining three *C. tlagu* specimens correspond to the following paratypes in Table 1: 242222 (UAM:Ento:135818), 242225 (UAM:Ento:159119), and 242226 (UAM:Ento:154335).

Systematics

***Caurinus tlagu* Sikes & Stockbridge, sp. n.**
urn:lsid:zoobank.org:act:BFFF780A-737D-4187-8539-32270D80D4C5
http://species-id.net/wiki/Caurinus_tlagu

Holotype. Male (in UAM), here designated, labeled "USA: Alaska, Prince of Wales Is. Hatchery Ck.4, 30 May-14 June 2010, 55.88433°N 132.89734°W ± 26m, 82m elev., thinned secondary growth with 18 ft. spacing between trees, pitfall 3, J. Stockbridge, C. Bickford" , / "HOLOTYPE *Caurinus tlagu* Sikes & Stockbridge 2013 UAM:Ento:142986" [red paper]. doi: 10.7299/X7GH9J4M

Paratypes. 36 Specimens (Table 1). The following 17 paratypes will be deposited in the collections indicated: male UAM:Ento:159146, female UAM:Ento:142985, female UAM:Ento:235025 (CAS); male UAM:Ento:229945, female UAM:Ento:235024, female UAM:Ento:229942 (OSAC); male UAM:Ento:235026, female UAM:Ento:203239, female UAM:Ento:203011 (PMJ); male UAM:Ento:167053, female UAM:Ento:229944, female UAM:Ento:235023 (SEMC); male UAM:Ento:217990, female UAM:Ento:221708, female UAM:Ento:159120 (USNM); male UAM:Ento:229943, female UAM:Ento:230091 (MTEC), and the 19 remaining in UAM.

Type Locality. USA: Alaska, Prince of Wales Is. Hatchery Ck, 55.88433°N 132.89734°W ± 26m, 82m elev. (Fig. 1, 2A).

Measurements. Restricted to specimens with retracted genitalia (3 males, 10 females), length, min. – max., mean ± SD : male 1.58–2.02, 1.74 ± 0.24 mm, female 1.64 – 2.00, 1.79 ± 0.13 mm.

Diagnosis. Circumference of eye of males comprises 31-35 (n=3) ommatidia (*C. dectes* males have 38–39, n=3). Scanning electron microscope-level resolution is required to obtain reliable counts (Fig. 4). Female 8th sterna without a median notch (n=10), or with a shallow median notch (n=5) (Fig. 5A,C, 6C,D). *Caurinus dectes* females have a shallow median notch or a pronounced median notch (Fig. 5B, see also Russell [1979b] fig. 10). This is visible at 40× and higher magnification.

Description. Body length 1.5–2.3 mm, flea-like in lateral view, color reddish brown, sparsely pubescent, strongly sclerotized (Fig. 6). Rostrum absent or reduced. Clypeolabral suture present. Clypeus divided into post and anteclypeus. Penultimate maxillary palpomere enlarged and club shaped. Antennal insertion lateral, widely separated. Ocelli absent. Antennae with sixteen antennomeres and a single countersunk sensilla on antennomeres 4, 5, and 6 (Fig. 7). Mandible with two subapical teeth (Fig. 6B). Male forewings extend to end of first abdominal segment, with six bristles (Fig. 8A), hindwings absent. Female forewings pad-like, hindwings absent. Tarsi five segmented, tarsal claws present. Pilosity absent. Abdomen widest at segments 4 and 5, segments 2-6 fused, annular. Male 8th tergum and sternum not fused. Male 9th tergum and sternum not fused. Genitalia normally concealed in both sexes. Male gonostyles flattened, deeply incised (Fig. 8B).

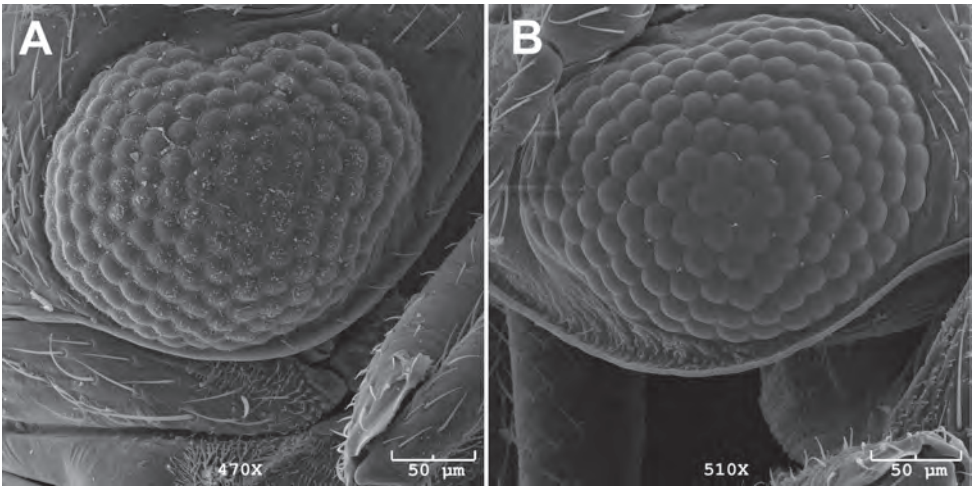

Figure 4. Eye of **A** male *Caurinus dectes* (UAM:Ento:230088) showing 38 ommatidia around circumference of right eye, dorsal is to the left, and **B** male *Caurnius tlagu* (UAM:Ento:202344) showing 35 ommatidia around circumference of left eye, dorsal is to the right. Scale bar = 50 µm.

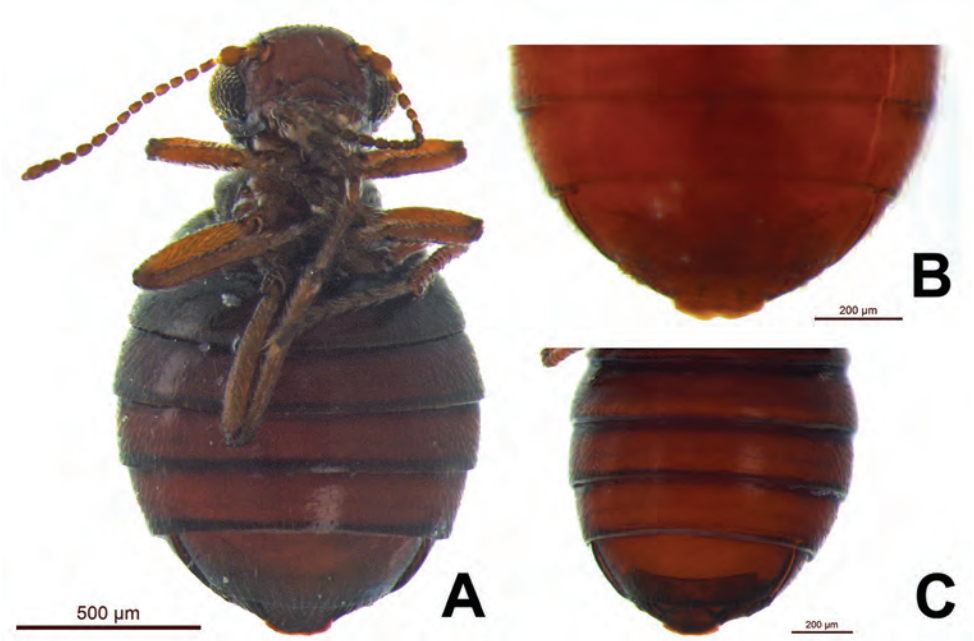

Figure 5. A ventral view of female *Caurinus tlagu* (UAM:Ento:203239) showing 8th sternum with shallow median emargination / notch, scale bar = 500 µm **B** ventral view of abdomen of female *Caurinus dectes* (UAM:Ento:228458) showing 8th sternum with a pronounced notch, scale bar = 200 µm **C** ventral view of abdomen of female *Caurinus tlagu* (UAM:Ento:203011) showing 8th sternum with shallow emargination / notch, scale bar = 200 µm.

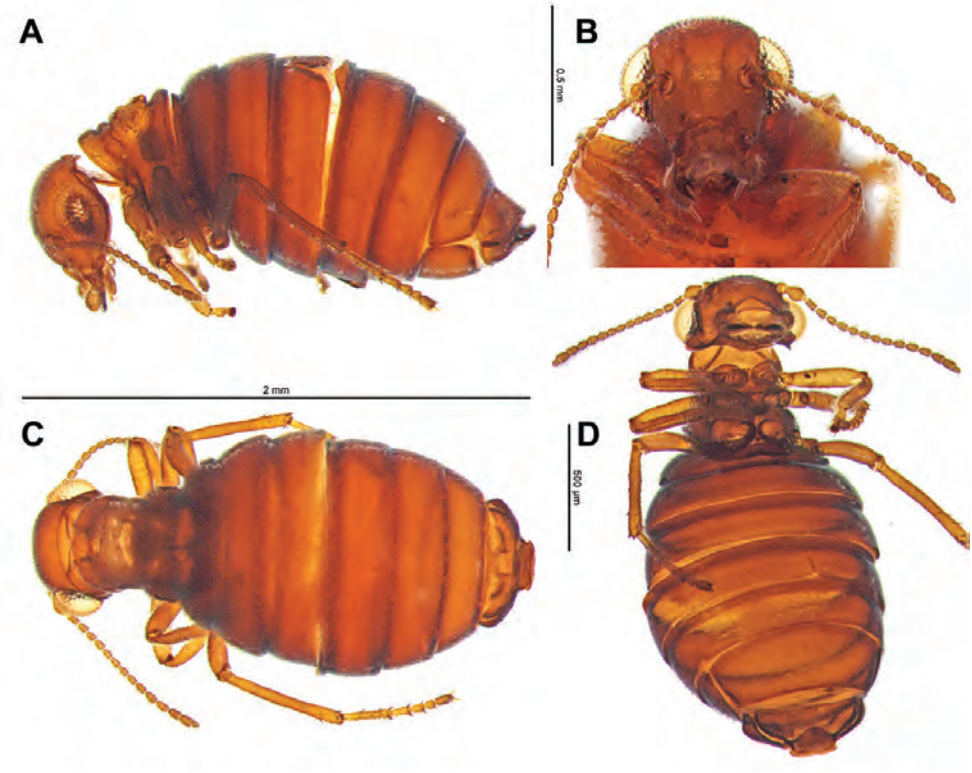

Figure 6. Female *Caurinus tlagu* (UAM:Ento:159119) that had been cleared in KOH. **A** lateral view (broken abdomen), scale bar = 2 mm **B** face, scale bar = 0.5 mm **C** dorsal view, scale bar = 2 mm **D** ventral view, scale bar = 0.5 mm.

Variation. One male (UAM:Ento:231726) has 7 bristles on its right wing, as a result of a very small extra basal bristle, and six on its left.

Geographic Distribution and Habitat. This species is only known from the northern half of Prince of Wales Island within a region about 45 km in size (Fig. 1). It was collected in forest habitat of various stages: old growth, secondary growth (thinned and unthinned), and young clear cuts; in addition to two specimens caught in alpine heath habitat and one in an ecotone of clearcut / secondary forest. The species is not restricted to lowland forests, nor to old growth forests.

Etymology. "*Tlagu,*" pronounced "tlu-gu," is derived from the Alaska Native tribal language Tlingit meaning "ancient, forever" (Crippen 2013) or "old, from the past" (Edwards 2009). Bierhorst (1985) provided this elaboration: "Among the Tlingit, for example, there are two kinds of stories, *tlagu* (of the long ago) and *ch'kalnik* (it really happened)." We name this species in honor of the place it occurs, its people, and history, in addition to the apparent great age of the genus *Caurinus*.

Discussion

Diagnostic characters were not easily found. These species are very similar phenotypically. The use of ommatidia counts around the circumference of the eyes of males (females we examined overlapped in these counts) is certainly not an ideal character because it is limited to one sex and requires SEM imaging to obtain accurate counts. In part because of this difficulty, and the rarity of specimens, our sample sizes for the assessment of this character are suboptimal. Despite these small sample sizes (n=3 for each species) the means differ significantly based on an unpaired, two-tailed student's t-test ($p = 0.0142$). We hope that ongoing morphological study of the Mecoptera by Rolf Beutel and others (e.g. Beutel et al. 2008) will better document variation between and within these *Caurinus* species.

During our examination of characters we compared both species for the paired cupuliform and countersunk antennal sensilla described by Beutel et al. (2008, fig. 3D) as occurring on the distal part of antennomeres 3 and 4. We found these on antennomeres 4, 5, and 6 (Fig. 7) but could not find them on antennomere 3 of either species. Also, we found the countersunk sensillum but not the cupuliform sensillum. We studied 5 specimens of *C. dectes* and 5 of *C. tlagu*, 3 males and 2 females of each, and were able to see sensilla on 2 female *C. dectes* and 1 male and 2 female *C. tlagu* but on no others. A shorter type of setae with a thicker apex is present near the countersunk sensilla (Fig. 7) which were also visible on those specimens on which we did not find sensilla. This lack of confirmation is likely due to the fixed positioning of the specimens for SEM imaging hiding the sensilla from view, although infraspecific variation and absence cannot yet be eliminated as explanations. The lack of sensilla on antennomere 3 of *C. dectes* raises the possibility that there are multiple species under the name *C. dectes*.

We examined the gonostyles of the males (Fig. 8B) for diagnostic characters. These complex structures may still hold diagnostic potential. In particular, the apex of the

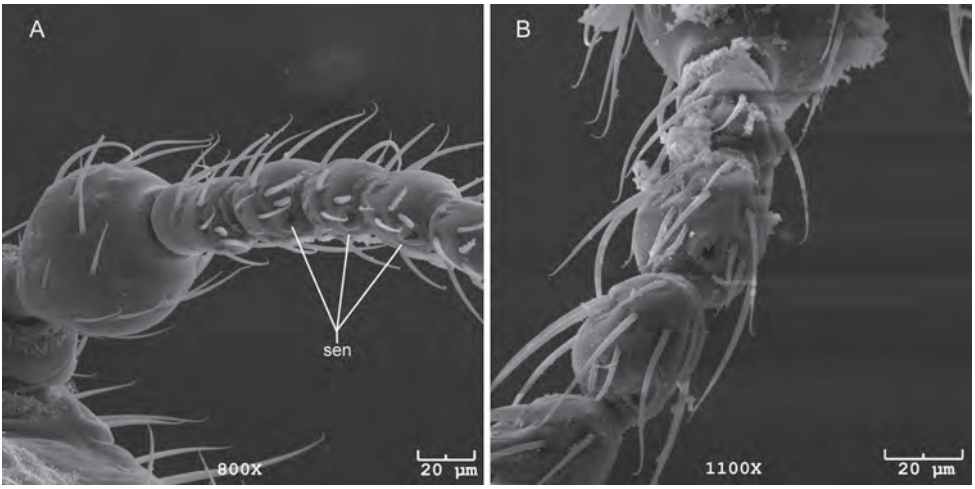

Figure 7. Base of *Caurinus* antenna showing sensilla on antenomeres 4, 5, and 6. **A** female *Caurinus dectes* (UAM:Ento:230088), **B** female *C. tlagu* (UAM:Ento:203237); sen = sensilla, scale bars = 20 µm.

gonostyle's setose basal tooth appeared tapered in *C. tlagu* and truncate in *C. dectes*. However, we were not able to confirm this state was constant in each species. The shape of the upper blade and the pattern of scale-like ridges on the upper blade also appeared to differ. Further study indicated these differences were probably due to differences in the available angles of viewing within the SEM.

We do not know the explanation for the very large COII difference (21.7%) seen between the GenBank *C. dectes* record and our own sequences of seven *C. dectes* specimens. Both samples were made by the same collector, and author of the species, L. Russell, from the type locality. The GenBank record for the *C. dectes* COII is 4.5% different from that of the GenBank record for *Panorpa debilis* (AF424023.1) from the same study (Whiting 2002) which suggests possible contamination or data mixup. Given the ambiguity of the GenBank record's accuracy we decided to exclude it from our analyses.

The two specimens recovered from the treeless alpine tundra site appear to violate characterizations of *Caurinus* being a forest associated lineage. However, *C. dectes* is often recovered from forested and open rocky sites with the common moss *Rhytidiadelphus loreus*, which represented 20% of the total vegetation at the alpine site (K. LaBounty pers. com.). That *C. tlagu* occurs in clear-cuts and secondary growth sites suggests it is not a habitat specialist. However, within the secondary growth sites in which *C. tlagu* was found, it was significantly more common in thinned sites (n= 11) than in unthinned (n=1). The former have been opened by the Forest Service program TWYGS (Tongass Wide Young Growth Studies) in which the trees have been thinned to encourage old-growth conditions whereas the latter habitats are closed-canopy and dark due to the overcrowding of even-aged trees. This does raise questions about the feeding and breeding ecology of *C. tlagu*. Russell (1979b, 1982) documented *C. dectes* as a specialist on epiphytic and terrestrial leafy liverworts (Jungermanniales). We lack

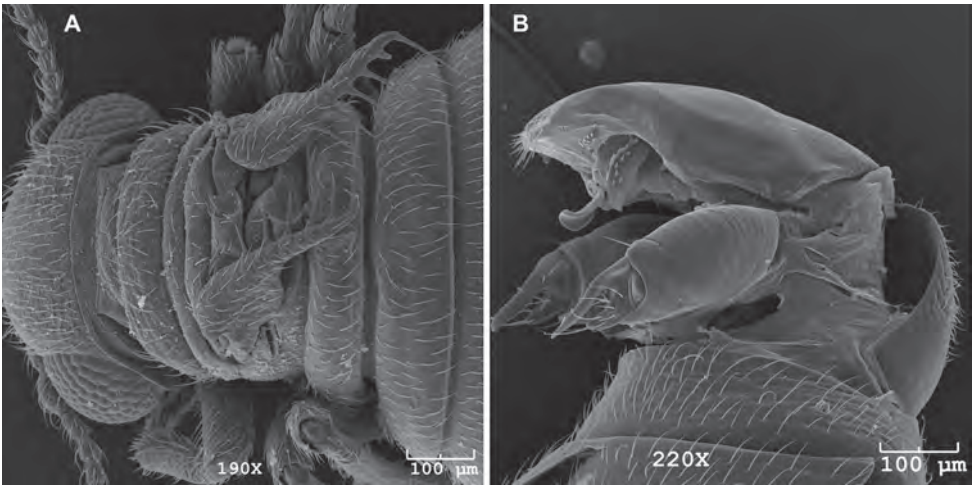

Figure 8. SEM images of male *Caurinus tlagu* (UAM:Ento:204239), scale bars = 100 µm **A** dorsal view showing wings **B** everted genitalia showing paired gonostyles, oblique lateral view.

adequate data on the bryophyte communities of the lowland forested sites to assess whether *C. tlagu* shows the same bryophyte associations as *C. dectes.* In particular, seven specimens (19% of our total catch) were found in recently deforested clear cuts, which are likely to have highly disturbed bryophyte communities.

Another notable difference between these *Caurinus* species may be their phenology. Russell (1982) describes adult *C. dectes* as primarily active during the winter (October – April), but reappearing in unseasonably wet, cool weather during the summer. This contrasts with our findings of summer presence of adult *C. tlagu*. Of course, *C. tlagu* could also be active year-round but our sampling regime would fail to detect anything but summer activity.

Various plausible scenarios exist to explain the 1,059 km range disjunction and presumed allopatric speciation within this genus of wingless mecopterans. Either or both populations could be the result of ancient (paleoendemism) or recent (neoendemism) dispersal from the other population or elsewhere (now extinct, or as yet unfound). Such dispersal could be as simple as the ancient transport of *Caurinus*-laden bryophytes by a bird. Given the genetic divergence between the populations, human transport is unlikely because it would be too recent. Alternatively, and we think more likely, both populations may be relicts of an ancient, and much larger population, with subsequent intervening extinction (paleoendemism). A multi-locus population genetics analysis with incorporation of data regarding the region's geological history would be needed to test these alternatives. Finally, these animals are not easily found and undetected populations may occur in intervening British Columbia.

Prince of Wales Island was mostly buried under an ice sheet during the maximum of the late Wisconsin glaciation 26,000 to 13,000 ^{14}C years BP (Carrara et al. 2007) and had been repeatedly buried by ice during the Pleistocene. However, considerable biological and geological evidence suggests that ice-free refugia may have existed during this time, allowing many diverse taxa to continue to evolve in relative isolation, and re-seed the region after deglaciation (Carrara et al. 2007). Of 108 mammal species or subspecies occurring in southeastern Alaska, 27 are endemic to the area (Cook et al. 2001). The known locations of *C. tlagu* are in regions that were reconstructed as under ice by Carrara et al. (2007, fig. 3). Post deglaciation dispersal to these sites from ice-free refugia is the most likely explanation. This suggests, and it would be likely regardless, that *C. tlagu* is more widely distributed than we have documented.

Despite their strong phenotypic similarity, the weight of the evidence supports the conclusion that these separate populations are not conspecific. Their mtDNA sequences being 7.17% divergent (corrected for multiple hits) suggests they have been isolated for probably less than 10 million years (Klicka and Zink 1997, Papadopoulou et al. 2010). Regardless, they have probably been isolated for longer than *Boreus westwoodi* and *Boreus hyemalis* have been isolated from each other. This degree of separation eliminates a late Pleistocene (100,000–250,000 YBP) speciation event hypothesis. The corrected genetic distances between *Boreus* and *Caurinus* (over 103%), indicate the COII gene is fully saturated with multiple hits at this level of comparison, and support the hypothesis of Russell (1979b) that *Caurinus* is a lineage of great age and not

an example of relatively recent evolutionary reversal that would make the Boreinae paraphyletic.

This suggests the split between the genus *Caurinus* and the remaining boreids likely predates the oldest confirmed boreid fossil, *Palaeoboreus zherichini* Sukatsheva & Rasnitsyn, of the Late Jurassic (Grimaldi and Engel 2005) which appears to be a boreine due to its size and external ovipositor, although it lacks the produced rostrum typical of extant species (Russell pers. com.). If confirmed, such a great age (>145 Ma) for a genus of two extant species would make the lineage an evolutionary relict and its species certainly deserving of conservation attention (Habel and Assmann 2010, Naskrecki 2011).

Acknowledgments

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Addendum

During 16–17 May 2013, Loren Russell, the author of *C. dectes* and authority on the ecology of the genus, joined us on Prince of Wales to collect and study *C. tlagu*, and show us how to target its host bryophyte. It took us two years (2010 and 2011) to collect 37 *C. tlagu* specimens using three structured sampling methods at 24 sites. In a few hours of collecting, L. Russell was able to collect over a dozen *C. tlagu* and taught us how to brush them from one of their preferred hosts (*Scapania bolanderi*). A video of L. Russell showing this method is available at https://vimeo.com/68819818 and a second video showing *C. tlagu* hopping is available at https://vimeo.com/68819819. Russell also alerted us to an earlier, ecological study that documented *Caurinus* from the Maybeso Experimental Forest on Prince of Wales Island (LeSage et al. 2005). We were able to confirm that voucher specimens of *Caurinus* from this 2005 study are deposited in the Michigan State University collection.

Proposed by:	**Mayor Cremata**
Attorney Review:	**10/16/2019**
Vote:	**5 Aye 0 Nay 1 Absent**

MUNICIPALITY OF SKAGWAY, ALASKA
RESOLUTION NO. 19-32R

A RESOLUTION OF THE MUNICIPALITY OF SKAGWAY, ALASKA EXPRESSING THE MUNICIPALITY OF SKAGWAY'S SUPPORT FOR ALTERNATIVE 1 OF THE DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE MANAGEMENT OF INVENTORIED ROADLESS AREAS WITHIN THE TONGASS NATIONAL FOREST.

WHEREAS, the community of Skagway is highly dependent on tourism as its main economic driver; and

WHEREAS, tourism in Skagway, the Inside Passage, and the broader region of Southeast Alaska is dependent on maintaining pristine, wild landscapes of the surrounding coastal temperate rainforest and the iconic wildlife it supports; and

WHEREAS, in 2001, the U.S. Department of Agriculture (USDA) finalized a management plan for the Tongass National Forest, which includes the National Roadless Area Conservation Rule (Roadless Rule) in response to disappearing wildlands and a road maintenance backlog of $8.4 billion; and

WHERES, the intent of the Roadless Rule was to protect the social, economic, and ecological values and characteristics of inventoried roadless areas from road construction and reconstruction and certain timber harvest activities; and

WHEREAS, at the time of promulgation in 2001, the Roadless Rule had the most extensive public involvement of any rulemaking process in the history of federal rulemaking, generating over 1.6 million comments, the vast majority of which supported the creation of a strong national policy protecting roadless areas; and

WHEREAS, inventoried roadless areas provide large, relatively undisturbed blocks of important habitat for a variety of terrestrial and aquatic wildlife and plants; contribute to healthy watersheds and clean drinking water; and provide extensive opportunities for outdoor recreation and tourism; and

WHEREAS, the Roadless Rule protects some of the last remaining tracts of old-growth forest habitat in the Tongass that contribute to the absorption of global warming pollution and protect native animal species that rely on them; and

WHEREAS, roadless areas support subsistence lifestyles through hunting and fishing, and support outdoor recreation and tourism industries; and

WHEREAS, the Roadless Rule contains a variety of exceptions that allow roadbuilding for community access, hydropower projects, utility connectors, and other economic development projects when they serve a legitimate public interest; and

WHEREAS, protection of these roadless areas in the Tongass National Forest is of local and national importance; and

WHEREAS, in 2018, the State of Alaska petitioned the USDA to craft a state-specific roadless rule and requested that a full exemption be pursued from the 2001 Roadless Rule; and

WHEREAS, in 2018 the USDA accepted the State of Alaska's petition and initiated a National Environmental Policy Act review, an environmental impact statement (EIS), and public rulemaking process to address the management of inventoried roadless areas within Alaska, and to evaluate the exemption set forth in the petition. The USDA rulemaking is administrative and separate from any action Congress may take; and

WHEREAS, the majority of comments received by the USDA following its notice of intent of proposed rulemaking opposed changing the Roadless Rule for Alaska; and

WHEREAS, the draft EIS provides an analysis of six alternatives related to roadless management in Alaska, ranging from no action to a full exemption from the Roadless Rule on the Tongass National Forest; and

WHEREAS, the USDA has identified Alternative 6, which is a full exemption, as the preferred alternative at this time; and

WHEREAS, the Municipality of Skagway opposes Alternative 6 and feels that Alternative 1, which requests no action and would maintain the 2001 Roadless Rule on the Tongass National Forest, best protects public interests while also protecting the unique ecosystem of the Tongass; and

WHEREAS, the USDA is seeking public comment on the draft EIS from October 18, 2019 to December 17, 2019 and will issue its decision regarding and Alaska Roadless Rule in June of 2020;

NOW THEREFORE BE IT RESOLVED THAT: the Skagway Borough Assembly expresses its opposition to Alternative 6, and its support for Alternative 1 of the draft environmental impact statement for the management of inventoried roadless areas within the Tongass National Forest.

PASSED AND APPROVED by a duly constituted quorum of the Borough Assembly of the Municipality of Skagway this 24th day of October, 2019.

Andrew Cremata, Mayor

ATTEST:

Emily A. Deach, Borough Clerk

(SEAL)

1 April 2007

Habitat Selection by American Martens in Coastal California

KEITH M. SLAUSON, WILLIAM J. ZIELINSKI, JOHN P. HAYES

Author Affiliations +

KEITH M. SLAUSON,[1,*] WILLIAM J. ZIELINSKI,[2] JOHN P. HAYES[3,]**

[1]aDepartment of Forest Science, 321 Richardson Hall, Oregon State University, Corvallis, OR 97331, US
[2]bUnited States Department of Agriculture Forest Service, Pacific Southwest Research Station, Redwood
[3]cDepartment of Forest Science, 321 Richardson Hall, Oregon State University, Corvallis, OR 97331, US

[*] Present address: United States Department of Agriculture, Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521, US
[**] Present address: Department of Wildlife Ecology and Conservation, University of Florida, 110 Newins-Ziegler Hall, Gainesville, FL 32611, USA

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Abstract

We investigated habitat selection using single- and mixed-scale modeling at 2 spatial scales, stand and home range, by the only known population of American martens (*Martes americana*) remaining in the historical range of the Humboldt subspecies (*M. a. humboldtensis*) in California, USA. During 2000 and 2001, we sampled a 12 × 14 grid with 2-km spacing, using 2 sooted track plates at each grid point. We detected martens at 26 of the 159 grid points. We used resource selection probability functions and an information-theoretic method to model habitat at detection locations. At the stand scale, martens selected conifer-dominated stands w dense, spatially extensive shrub cover (¯ = 74% cover, SE = 4) in the oldest developmental stage. At the home-range scale, martens selected the largest available patches (¯ = 181 ha, SE = 14) of old-growth, old-growth and late-mature, or serpentine habitat. Mixed-scale models revealed that habitat characteristics from both scales best explained marten occurrence compared to one scale alone. Dense, spatially extensive shrub cover is a key habitat element for martens in coastal forests. Dense shrubs provide refuge from predators, cover for prey, and may also deter larger-bodied competitors. Managers can increase the likelihood of marten populati persistence and encourage expansion in coastal forests by maintaining and restoring late-mature and old-growth, conifer-dominated forests with dense shrub cover large, contiguous patches.

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Spatially explicit analysis of contributions of a regional conservation strategy toward sustaining northern goshawk habitat

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Original Article

Spatially Explicit Analysis of Contributions of a Regional Conservation Strategy Toward Sustaining Northern Goshawk Habitat

WINSTON P. SMITH,[1] *Institute of Arctic Biology, University of Alaska, Fairbanks, 2571-3 Douglas Highway, Juneau, AK 99801, USA*

ABSTRACT Setting aside habitat is a common strategy to maintain viable wildlife populations, but underlying assumptions or effectiveness are rarely evaluated. The Tongass National Forest prioritized habitat management for sensitive species in Southeast Alaska's rainforest, and standards and guidelines were established for northern goshawks (*Accipiter gentilis*). I used guidelines from other portions of its range and data from Southeast Alaska, USA, to evaluate the conservation strategy. I used published data and nests from this study to define choice habitats; published juvenile movements and female use areas were used to estimate an "average" post-fledging area and female breeding range, respectively. I used nest-tree locations ($n = 136$) to delineate corresponding virtual post-fledging areas and female home ranges, within which I calculated acreage of 4 cover-type and 4 land-use categories. About 30% of nests had >51% of post-fledging areas in choice habitat; 60% of nests had >51% in unsecure (unprotected from development) land-use designations, whereas 16% had >51% in a protected old-growth designation. The female range was similar to post-fledging areas, but the proportions predominantly (>75%) available for development (land use that modifies landscapes) or with 26–50% of total area in choice habitat were larger than post-fledging areas, and half as many nests had >51% of area in choice habitat. Among cover types, choice habitat averaged 39.4% of the post-fledging area. These findings increase uncertainty about conservation measures contributing sufficient habitat to sustain well-distributed, viable populations of northern goshawks throughout Southeast Alaska and demonstrate the need and feasibility of evaluating assumptions of conservation plans.
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KEY WORDS *Accipiter gentilis*, conservation strategy, land-use planning, northern goshawk, population viability, southeastern Alaska, temperate rainforest.

Maintaining biological diversity, especially viability of endemic organisms, continues to rank high among land-management issues on public (Possingham et al. 1993, Szaro and Johnston 1996, Iverson and René 1997, Smith and Zollner 2005) and private lands (Lindenmayer and Possingham 1996) because wildlife species are valued by many segments of society (Naess 1986, Catton and Mighetto 1998) and because persistence of indigenous wildlife populations at "ecologically effective" densities (*sensu* Soulé et al. 2003, p. 1,239) is a crucial component of healthy ecosystems (Pimm 1991, Petchey 2000, Pyare and Berger 2003, Soulé et al. 2003). Loss or fragmentation of habitats due to human activity are directly associated with the rapid decay of ecological and evolutionary diversity worldwide (Pereira et al. 2004, Reed 2004). Undoubtedly, global demands for natural resources will continue to increase and land managers will experience greater and more complex challenges to safeguarding ecosystem functions (Costanza et al. 1997, Newton and Freyfogle 2005).

In Southeast Alaska, USA, the Tongass National Forest responded to challenges of sustaining viable and widely distributed wildlife populations across the planning area by developing a comprehensive, regional conservation plan. The 1997 Tongass Land and Resource Management Plan established a system of small, medium, and large reserves to provide large areas of protected, intact old-growth forest and site-specific standards and guidelines to manage locally important habitat for sensitive species (U.S. Forest Service 1997). A fundamental assumption was that lands managed for timber production would contribute little toward maintaining well-distributed and viable populations (U.S. Forest Service 1997: appendix N); rather, reserves and other protected lands would provide sufficient habitat to sustain indigenous wildlife (Iverson and René 1997).

Setting aside essential habitat is a common strategy to maintain indigenous wildlife in modified landscapes, but the underlying assumptions or the effectiveness of such strategies are rarely evaluated (Smith et al. 2011). Although land-use or conservation plans typically stipulate long-term effectiveness monitoring of framework elements and specific measures (U.S. Forest Service 1997: chapter 6), the costs required to do so often are prohibitive, and thus monitoring plans rarely are fully implemented (Patla 2005, Smith et al. 2011). More importantly, irreparable negative impacts can occur before long-term monitoring uncovers flaws in the underlying conceptual framework, or

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[1]*E-mail: wsmith58@alaska.edu*

in deficiencies in the implementation of specific management guidelines or conservation measures (Smith et al. 2011). However, Smith and Person (2007) demonstrated the feasibility and value of evaluating elements and assumptions of the underlying theoretical framework of a regional conservation plan.

The northern goshawk (*Accipiter gentilis*) in Southeast Alaska received special consideration as a "sensitive species" in the revised forest plan (U.S. Forest Service 1997, pp. 4–89), in part because of concerns over the viability of endemic Queen Charlotte goshawk (*A. g. laingi*) populations (Iverson et al. 1996, Iverson and René 1997, U.S. Fish and Wildlife Service 2007). Standards and guidelines for forest management actions were established using important ecological aspects of this species' biology (Iverson et al. 1996). The 1997 standard and guidelines specific to goshawk reproduction stipulated that managers should "preserve nesting habitat around all confirmed and probable nest sites" (U.S. Forest Service 1997, pp. 4–89) and included several criteria for identifying nest sites and guidance related to achieving this objective.

Much of the science used to develop the Tongass standards and guidelines and policy for managing habitat for northern goshawks was based on studies conducted elsewhere because local information was largely unavailable (Iverson et al. 1996). Since 1997, however, considerable effort has yielded valuable empirical data about the life history, ecology, and habitat needs of northern goshawks in Southeast Alaska, especially during the breeding season (Flatten et al. 2001, Lewis et al. 2006). In addition, there have been numerous studies and reviews completed throughout its range (Penteriani 2002, Andersen et al. 2005, Greenwald et al. 2005, Boal et al. 2006). Moreover, reviews and studies in British Columbia, Canada, have substantially increased our knowledge about goshawks in temperate rainforests (Cooper and Stevens 2000; McClaren et al. 2002, 2003, 2005; Mahon and Doyle 2005, Doyle 2006).

In western North America, the breeding home ranges of northern goshawks often are represented as a hierarchical sequence of 3 areas (Andersen et al. 2005), all of which need to be considered simultaneously in land-use planning or mitigation (Reynolds et al. 2006, Northern Goshawk *Accipiter gentilis laingi* Recovery Team 2008): 1) nest area, 2) post-fledging (family) area, and 3) foraging area. Nest areas provide alternate nest trees, roost trees, prey-plucking posts, and serve as centers of essential breeding behaviors or life-history events (Reynolds et al. 1992, 2006). Post-fledging areas surround active nest trees and represent the core-use area of an adult female and of young goshawks after fledging but before becoming independent of adults and dispersing (Kennedy et al. 1994). McClaren et al. (2005) suggested the biological role of post-fledging areas and nest areas are similar and therefore it is useful to consider them as one functional component. Regardless, the habitat composition (i.e., overstory) of post-fledging areas should be similar to nest areas (Reynolds et al. 2008). Foraging areas comprise the majority of northern goshawk breeding home ranges and are especially important for adults providing food to young and for juveniles prior to natal dispersal. Adults may have foraging areas that are a considerable distance from nests and may change their foraging areas seasonally or from 1 year to the next (Titus et al. 1994). Foraging areas generally are large ($\geq$2,000 ha) but vary among localities and according to individual experience, hunting efficiency, food requirements (brood size), and availability of food within home ranges (Kennedy et al. 1994). Also, the combined home range of male and female pairs can be substantially larger than that of individual birds (Boal et al. 2003). The most imminent threats to breeding populations are loss or fragmentation of nesting and foraging habitat, especially reductions in prey diversity and availability (Reynolds et al. 1992, 2006, 2008; Finn et al. 2002, McGrath et al. 2003, Salafsky et al. 2007, Northern Goshawk *Accipiter gentilis laingi* Recovery Team 2008).

Despite a substantial increase in knowledge since the revision of the 1997 Tongass Land and Resource Management Plan, the implications of those new insights to goshawk conservation and land-use policies in Southeast Alaska have not been rigorously examined. In particular, it is unclear whether a system of old-growth reserves designed explicitly for other wildlife species and protection of goshawk nest trees in landscapes intensively managed for timber (clearcut logging) would provide sufficient habitat to sustain breeding populations of the northern goshawk across the planning area (Finn et al. 2002). The purpose of this study is to evaluate the underlying framework and assumptions of the Tongass conservation strategy to sustain well-distributed, breeding populations of a species whose home range encompasses entire watersheds and whose life history in Southeast Alaska appears to require vast amounts of old-forest habitat (Iverson et al. 1996). To accomplish this, I undertook a spatially explicit analysis that quantified contributions of the 1997 Tongass conservation strategy toward sustaining suitable habitat in 2 essential components of northern goshawk breeding pairs' home ranges: post-fledging area and breeding home range of females. Specific objectives were to 1) use the findings of habitat-use analyses from Southeast Alaska (Iverson et al. 1996) in conjunction with the observed habitat composition of nest sites to identify choice habitat for nest areas; 2) use juvenile post-fledging movements to estimate the radii of circular, virtual post-fledging areas and broader landscapes represented by the median 90% minimum convex polygons breeding home range ("use areas," Iverson et al. 1996) of females; 3) quantify contributions (total acreage) of the Tongass conservation elements to conserving secure (protected from development) habitat in projected goshawk post-fledging area and female breeding home ranges; 4) compare the cover-type composition of virtual post-fledging areas with the observed composition of nest sites in Southeast Alaska and to published recommendations for post-fledging area composition (Reynolds et al. 1992, 2006, 2008); and 5) classify projected northern goshawk post-fledging and breeding home ranges according to the extent (percentage categories) that the habitat composition

approached recommended guidelines or the observed percentages of habitat types among nest sites in Southeast Alaska.

STUDY AREA

The Tongass National Forest encompassed about 95% of southeastern Alaska; this included the Alexander Archipelago with thousands of islands, and a narrow mainland region that extended from Dixon Entrance (54°30′N latitude) to the Malaspina Glacier (59°45′N latitude; U.S. Forest Service 1997). The Tongass was unique among national forests in several ways (Everest et al. 1997), including a dynamic geological history, naturally fragmented and isolated landscapes, and extraordinary environmental complexity (MacDonald and Cook 1996).

Southeastern Alaska had glaciated mountain ranges and fjords, and a cool, wet (200- to 600-cm precipitation) maritime climate with mean monthly temperatures ranging from 13° C in July to 1° C in January (Searby 1968). About 4 million ha (60%) was forestland (U.S. Forest Service 1997), of which 2.2 million ha was productive forests (Julin and Caouette 1997). Coniferous rainforest dominated the landscape from shoreline to about 600 m elevation, with approximately 90% of productive forests in Sitka spruce (*Picea sitchensis*)—western hemlock (*Tsuga heterophylla*) forests, which typically are the old-growth forests of upland sites; remaining areas were alpine, muskeg, or riparian (Hutchinson and LaBau 1974). Unmanaged forests typically had a multi-layered overstory of uneven-aged trees, dominant trees that generally were >300 years old, and extensive, structurally diverse understories (Ver Hoef et al. 1988). These forests varied in structure from "scrub" or low-volume communities of short (<10 m), small (<0.5-m diam) trees with open canopies and dense, shrubby understories on poorly drained sites (peatland), to highly productive sites that supported high-volume stands with a closed canopy; tall (>60 m), large (>3-m diam) trees; and a predominantly herbaceous understory (Harris and Farr 1974, Alaback 1982). The *Tsuga–Picea* forest type constitutes most of the closed-canopy forests in the region (Alaback 1982). It was spatially heterogeneous at a fine scale—<1 ha (Schoen et al. 1984)—and typically occurred on low elevation, well-drained sites, frequently as a mosaic with muskegs (Neiland 1971). The primary disturbance was wind, with infrequent (100–200 yr) catastrophic windstorms blowing down tens to hundreds of hectares of old-growth rainforest, which produced relatively homogeneous, naturally regenerated second growth with dense canopies (i.e., wind-originated stands; Nowacki and Kramer 1998). More frequent, but less severe, windstorms blow down one or a few trees, which produces gap-phase old-growth stands with more fine-scale heterogeneity and much larger and older trees (Alaback 1982).

METHODS

Discerning Post-Fledging Area Habitat

I used the 2003 geographic information system (GIS) database of northern goshawk nest-tree locations obtained during 1989–2003 from annual surveys of nests conducted by the Tongass National Forest, Alaska Department of Fish and Game, and U.S. Fish and Wildlife Service (Flatten et al. 2001). Some nests were found by tracking radiocollared goshawks, coincidentally while conducting other fieldwork (e.g., timber sale surveys), or from reports by individuals recreating on the National Forest (Iverson et al. 1996). I updated the 2003 database with new nest trees obtained from surveys conducted through July 2005 by the Tongass National Forest and cooperators. Because many goshawk nests were located during timber-sale surveys or layout (Iverson et al. 1996), the relative amount of high- and medium-volume old growth distributed among land-use designations might have been biased toward the Development category (lands available for timber production and other uses that modify landscapes) as compared with a random sample collected across the region (Daw et al. 1998). However, Schempf et al. (1996) used standardized protocols to survey 724 points within 62 plots across 67 km^2 of roadless areas in Southeast Alaska. They recorded responses from only a single adult goshawk and concluded that the much lower (order of magnitude) detection rate (compared with similar surveys in other portions of this species' range) suggested a low density and widely dispersed goshawk population across the sampling area.

The desired condition of a post-fledging area is habitat composition similar to the nest area (Reynolds et al. 1992, McClaren et al. 2005). Therefore, I identified habitat for post-fledging areas by averaging the composition of cover types (e.g., old-growth forest, muskeg, managed forest) within nest areas of previously occupied nest sites in the region. Post-fledging area habitat was delineated according to the findings of an analysis of habitat selection during the breeding season that compared the proportion of radiotelemetry locations in each habitat type with the proportion that each corresponding habitat type comprised in "use areas" represented by 100% minimum convex polygons (Iverson et al. 1996). During the breeding season, goshawks selected high-volume (forest-wide mean ± 95% CI = 201.5 ± 4.7 m^3/ha) and medium-volume (146.2 ± 4.5 m^3/ha) strata old-growth forests (Julin and Caouette 1997). Mature sawtimber (75- to 150-yr second growth), low-volume (91.5 ± 4.5 m^3/ha), and scrub forests (<76 m^3/ha) received much less use, which did not differ from that expected according to availability; clearcut (approx. 0–40 yr) and non-forest cover types were avoided. Because nest areas typically are 10- to 12-ha areas immediately surrounding the nest site (Reynolds 1983; Reynolds et al. 1992, 1994), I used a 10.5-ha nest area to accomplish English GIS queries.

To discern available vegetation community types comprising goshawk habitat, I overlaid the location of each nest tree on a 2003 Tongass National Forest data layer of forest stand volume and totaled the area within each polygon that represented a unique volume strata of old-growth forest (low, medium, high). I summed total area of each stratum to determine relative composition of a nest area, centered on the nest tree, and to determine the frequency distribution of nest areas by low-, medium-, or high-volume old-growth

forest. Because the vast majority of second-growth was <50 years old (Barbour et al. 2005), mature sawtimber represented a very small (approx. 1%) component of the forested landscape. Scrub forests are peatlands with little or no forest canopy (Harris and Farr 1974). None of the 136 nests were in sawtimber or scrub forests. Therefore, I assumed that medium- or high-volume old-growth forests provided the resources needed by northern goshawks during the breeding season based on the previous findings of habitat selection (Iverson et al. 1996) and because nest trees were invariably in medium- or high-volume old-growth stands.

Composition of Virtual Areas

To determine contributions of the Tongass conservation strategy toward meeting breeding-season habitat objectives, I estimated the size of a post-fledging area in Southeast Alaska according to concepts in Kennedy et al. (1994), the behavior of post-fledged juveniles (Kenward et al. 1993), and published data on juvenile movements during the post-fledging period (Iverson et al. 1996). I used 1,600 m to estimate the average limit of all movements of post-fledged juveniles because this was assumed to be the distance that defined when juveniles were undertaking post-fledging movements (Kenward et al. 1993) and because 23 of 28 juvenile goshawks monitored with radiotelemetry in Southeast Alaska moved ≥1,600 m (Iverson et al. 1996). I then used this estimate of distance moved during the post-fledging period as the radius of circular areas centered on a nest to represent an "average post-fledging area." I used the median home range (90% mononuclear probability polygon; Iverson et al. 1996) of adult females during the breeding season (21 km^2) to delineate broader landscapes that comprised essential foraging habitat (Reynolds et al. 1992, 2006, 2008). Because goshawk males typically do most of the hunting during the nesting period (Kenward 1982), this approach assumes that the male's breeding-season range, which averaged about 50% larger than females, did not differ substantially in habitat composition. I overlaid each nest's virtual post-fledging area and breeding home range on GIS layers of cover types and land-use designations based on stand volume and management history. The area within each polygon that represented a unique land-use description was summed to determine relative composition of 4 land-use categories: Development—lands available for timber production and other uses that modify landscapes; Non-National Forest lands; Natural Setting—lands that maintain a natural setting, such as wild and scenic rivers and remote recreational areas; and Old Growth—protected old-growth forests. The same procedure was used to determine composition of 4 cover types: Habitat—high or medium-volume old-growth forests; Low—low-volume old-growth forests; Clearcut—all lands harvested between 1954 and 2005; Non-forest—all lands that do not support productive forests (Julin and Caouette 1997). The extent to which the female home range and post-fledging area differed in composition served as a metric of landscape heterogeneity that also provided insights about the sensitivity of this analysis to sampling error and the likelihood that habitat composition of male breeding ranges differed from females. Results are presented as separate summaries of average land-use designation or cover-type composition for post-fledging areas and seasonal home ranges.

RESULTS

Nest Area and Habitat

I determined habitat used by goshawks for the post-fledging area analysis using the habitat composition of 136 nest areas across the Tongass National Forest: overall, 100% of the nest trees were in productive (low-, medium-, or high-volume) old-growth forests, which comprised 66.1% (SD = 0.05) of goshawk nest areas. The remainder of nest areas was in scrub forests (fens), non-forested areas (muskegs), or regeneration stands following clearcut logging. A total of 58 nest areas primarily (>50%) consisted of high-volume old growth; 57 and 15 nest areas primarily consisted of medium- and low-volume old growth, respectively. Six nest areas did not contain any old-growth forest; according to notes in the database file, those nest trees were located in portions of the forest that were clearcut-logged after a breeding pair had selected a nest tree. If nest trees on clearcut sites or near a natural feature creating an abrupt forest edge (e.g., shoreline) were excluded ($n = 11$), mean proportion of productive old-growth forest in nest areas was 0.712 (SD = 0.041). The mean proportions of volume strata in the remaining nest areas ($n = 125$) were 0.097 (SD = 0.025), 0.283 (SD = 0.039), and 0.289 (SD = 0.039) for low-, medium-, and high-volume forests, respectively. Based on the habitat at 125 nest sites and within corresponding nest areas and on the findings of a previous habitat selection study (Iverson et al. 1996), I refer to medium- or high-volume old growth in virtual areas below as "choice habitat."

Land-Use Designation and Habitat Composition of Virtual Areas

The composition of land-use designations of an average post-fledging area contained a relatively large proportion of Development (land uses that modify landscapes) lands, with >30% of all nest areas having >91% of the post-fledging area as lands available for timber production (Fig. 1a; Appendix A). Cover-type composition of post-fledging areas contained a relatively large proportion of non-forest cover types (Fig. 1b). About 30% of the nests had >51% (i.e., 51–75%, 76–90%, or >90%) of the corresponding post-fledging area in medium- or high-volume old growth (choice habitat); 51% of nests had 26–50% of the post-fledging area in choice habitat. Most (60%) of this choice habitat was in the Development land-use designation or Non-National Forest designation (Fig. 1a); 16% of the nests had >51% of the post-fledging area in the Old-Growth land-use designation, with the remainder in Natural Setting. Across all nest areas, the Old-Growth land-use designation averaged 14.8% (100 ha; SE = 4.6) of the total post-fledging area acreage. Development, Non-National Forest, and Natural Setting averaged 41.1% (278 ha; SE = 7.6), 13.5% (91 ha; SE = 4.6), and 27.2% (184 ha; SE = 6.9), respectively. Among cover types, choice habitat averaged 39.4%

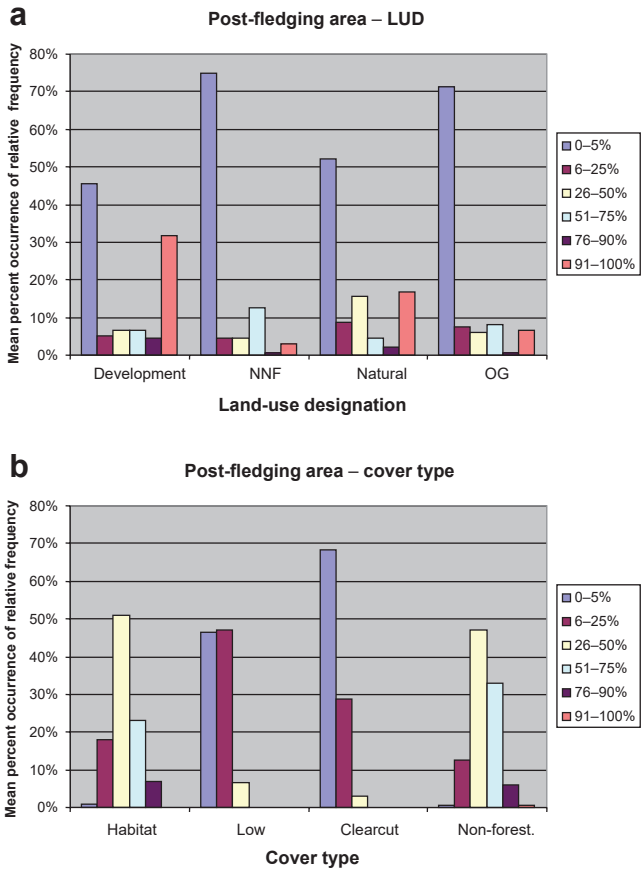

Figure 1. Mean percent occurrence of relative frequency (%) categories of land-use designations (a) and cover types (b) in 136 virtual northern goshawk (*Accipiter gentilis*) post-fledging areas (800 ha) in Southeast Alaska, USA. Total area was calculated from an estimate of the average post-fledgling movements (1,600 m), which served as radius of a circular area. Development = lands available for timber production and other uses that modify landscapes; NNF = non–national forestlands; Natural = lands that maintain a natural setting, such as wild and scenic rivers and remote recreational areas; and OG = protected old-growth forests. Cover types: Habitat = high- or medium-volume old-growth forests; Low = low-volume old-growth forests; clearcut = all lands harvested between 1954 and 2005; Non-forest = all lands that do not support productive forests (Julin and Caouette 1997).

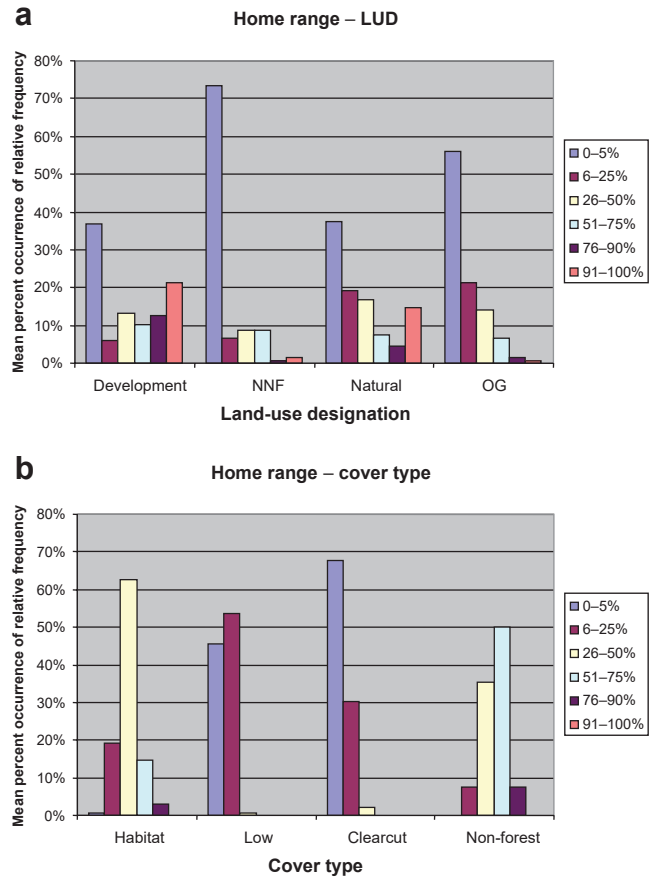

Figure 2. Mean percent occurrence of relative frequency (%) categories of land-use designations (a) and cover types (b) in virtual female breeding home ranges (2,100 ha) encircling 136 northern goshawk (*Accipiter gentilis*) nest sites in Southeast Alaska, USA. Total area was calculated from an estimate of goshawk movements (2,600 m), which served as radius of a circular area. Land-use designations: Development = lands available for timber production and other uses that modify landscapes; NNF = Non-National Forest Lands; Natural = lands that maintain a natural setting, such as wild and scenic rivers and remote recreational areas; and OG = protected old-growth forests. Cover types: Habitat = high- or medium-volume old-growth forests; Low = low-volume old-growth forests; clearcut = all lands harvested between 1954 and 2005; Non-forest = all lands that do not support forests (Julin and Caouette 1997).

(266 ha; SE = 9.3) of the post-fledging area; low volume forest, clearcut, and non-forest lands averaged 8.3% (56 ha; SE = 2.6), 3.9% (27 ha; SE = 1.5), and 45.0% (304 ha; SE = 10.3), respectively.

Similar results were obtained from an analysis of the female breeding home range, but with 3 notable differences. The percentage of this broader landscape that consisted predominantly (>75%) of lands available for development was greater than in post-fledging areas (Fig. 2a; Appendix A). The percentage of the total area with 26–50% of the total area in choice habitat also increased in comparison with the post-fledging area, whereas about half as many nests had ≥51% of this broader landscape in choice habitat as compared with the post-fledging area (Fig. 2b).

DISCUSSION

The 1997 Tongass Land and Resource Management Plan included multiple conservation measures to maintain habitat, with a goal of sustaining viable and widely distributed populations of indigenous wildlife throughout the planning area. Although some elements of the 1997 Tongass Land and Resource Management Plan have undergone revision, the wildlife conservation strategy remains largely unchanged (Smith et al. 2011). Individual species, such as the northern goshawk, received specific conservation measures to reduce viability risks (Iverson et al. 1996). According to the conservation assessment, implementation of the 1997 Tongass Land and Resource Management Plan for 100 years would result in "a moderately high likelihood of providing the amount and distribution of habitats to sustain long-term well distributed viable populations of goshawks throughout the Tongass" (U.S. Forest Service 1997: appendix N38). This long-term projection, an inherent assumption of the conservation strategy, was based on analyses at multiple spatial scales (U.S. Forest Service 1997). This study used contributions of various elements of the conservation strategy

to biological components of the breeding range centered on specific nest sites. This approach allowed an examination of the underlying assumption that the 1997 Tongass Land and Resource Management Plan provides habitat needed to sustain breeding populations of goshawks across the planning area. Productive old-growth forests unavailable for timber harvest were used frequently by northern goshawks and "thus the contribution of these habitats must be included in an assessment of overall risk to sustainability of goshawk habitat" (U.S. Forest Service 1997: appendix N38).

Standards and guidelines prescribed for protection of goshawk nest areas (40 ha) in Southeast Alaska are unlikely to meet breeding-season habitat objectives established for goshawk populations elsewhere (Reynolds et al. 1992, McClaren et al. 2005). The expectation that, in landscapes managed intensively for timber products, habitat contributed by other elements of the Tongass conservation strategy (e.g., old-growth reserves) will mitigate this deficiency was not supported by my analysis. An ideal northern goshawk home range consists entirely of older forests with small, dispersed openings (Reynolds et al. 2006, 2008). Guidelines for the composition of post-fledging areas stipulate that "the majority (60%)" of a post-fledging area should be in forest of older age classes (Reynolds et al. 1992, p. 23), which continues to be corroborated by further study in other portions of this species' range (Daw and DeStefano 2001), including temperate rainforests (McClaren et al. 2005). In my study, nest areas averaged 71% productive old growth; 58% of the nest area consisted of medium- or high-volume old growth. Before logging, landscapes across Southeast Alaska likely were similar in composition to current nest areas (U.S. Forest Service 1997). At the time of my study, only about one-third of 136 virtual post-fledging areas contained >51% choice habitat. More importantly, the average composition of "unsecure" (i.e., Development or Non-National Forest land-use designations) habitat was 55%, and 60% of all post-fledging areas consisted of >51% unsecure habitat. Regardless of whether I compare these results with guidelines from the southwestern United States or the habitat at nest sites and in nest areas of Southeast Alaska (i.e., desired future condition of goshawk post-fledging areas; Reynolds et al. 2008), the observed composition of post-fledging areas was less than the minimum recommended or desired amount of habitat.

This conclusion differs from a general forest-wide habitat availability assessment (i.e., not linked to specific goshawk nest sites) based on analyses at multiple spatial scales (U.S. Forest Service 1997: appendix N43). I believe the disparity can be explained by differences in scale and biological relevance (i.e., linked to specific life-history needs; Reynolds et al. 2006) of analyses between this study and previous analyses (Iverson et al. 1996, U.S. Forest Service 1997: appendix N38). Some of the analyses cited in the summary appraisal were at a regional scale (forest-wide) and spatially neutral. For example, the conclusion that 95% of the northern goshawk range in the region has a high likelihood of sustaining habitat because 93% of the forests would have <47% of productive old-growth harvested over the planning horizon provides little spatially explicit information about breeding-season habitat, especially for populations occurring on islands. Also, results of stand-level analyses cited in the summary largely focused on aspects of forest management that were not immediately relevant to the life-history needs of breeding pairs. Conclusions that only a small percentage of nest areas examined had experienced any logging or that only a small proportion of nest areas were harvested says little about breeding-season habitat or resources available to breeding pairs, especially across the broader landscape. Intermediate-scale analyses and protective measures, such as limiting total harvest to ≤33% of a watershed during the planning horizon (effectively a 300-yr rotation), are spatially explicit and potentially have biological relevance (i.e., approximate size of goshawk home ranges). However, management guidelines not explicitly coupled to northern goshawk breeding ranges or life history are at risk of not meeting habitat needs of individual breeding pairs (Reynolds et al. 2006, Northern Goshawk *Accipiter gentilis laingi* Recovery Team 2008).

At the time of the summary assessment (U.S. Forest Service 1997), about 5% (35/678) of the watersheds exceeded the stipulated threshold of total harvest, with 33–47% of the total available productive old-growth forests already harvested; 26 of those (74%) were concentrated in one Biogeographic Province (North Prince of Wales Island). The assessment acknowledged the higher risks of exceeding watershed thresholds of total harvest, especially across North Prince of Wales Island, but assumed that large reserves in those landscapes would mitigate the habitat loss from excessive timber harvest. The findings of this study suggest that contributions of old-growth reserves and other conservation elements (e.g., riparian or shoreline buffers) might not mitigate the cumulative habitat loss in intensively managed landscapes. This conclusion is supported by evidence on nearby islands that extensive loss and fragmentation of habitat from clearcut logging contributed to population declines of Queen Charlotte goshawks (Doyle 2006).

The threshold composition of suitable habitat to ensure successful breeding by goshawks in Southeast Alaska is unknown. To gain this knowledge requires extensive monitoring and research that chronicles reproductive histories of individual breeding pairs and links fitness to nesting habitat condition (Patla 2005, Reynolds et al. 2005, Salafsky et al. 2007). Still, the findings of this study increase uncertainty that northern goshawk breeding-season habitat objectives are being met in managed landscapes of Southeast Alaska. Two lines of reasoning support this conclusion.

First, spatially explicit analyses of contributions to northern goshawk breeding-season habitat revealed that conservation measures of the Tongass Land and Resource Management Plan contribute about half the secure habitat recommended for post-fledging areas of breeding pairs in the southern portion of this species range (Reynolds et al. 1992) and was less than half the relative amount of habitat documented in nest areas in Southeast Alaska. A similar conclusion was obtained for the broader landscape (21 km^2) that surrounded each nest. This is because much of the habitat across the

landscape has been clearcut-logged and half the remaining choice habitat is in the Development land-use designation available for timber harvest. The potential for second-growth stands to become useable habitat (mature sawtimber) over the Tongass planning horizon is limited because unmanaged second growth typically requires ≥300 years following disturbance to develop old-forest features (Nowacki and Kramer 1998). Active management can hasten the development of old-forest condition, but pre- and commercial thinning has occurred in only about 30% of 267,000 ha that have been harvested across the region (Barbour et al. 2005).

Secondly, guidelines developed for northern goshawk populations in the southwestern United States may underestimate habitat needed by breeding pairs in Southeast Alaska. A critical consideration in conserving habitat to support breeding populations is sufficient habitat to sustain prey resources (Reynolds et al. 2006; Salafsky et al. 2005, 2007). Despite possible differences in life history or ecology across the range of northern goshawks, the nesting and foraging habitat of successful breeding pairs must support adequate prey populations. In Southeast Alaska, the predominant (frequency and biomass) prey items during the breeding season (Lewis et al. 2006) are bird and mammal species that are most abundant, or occur exclusively, in productive old-growth forests (Iverson et al. 1996, Russell 1999; Smith et al. 2001, 2004, 2005). Consider further that the mammal fauna of Southeast Alaska is depauperate (MacDonald and Cook 1996); few mammal species exclusively occur in low-volume or managed forests of Southeast Alaska (Smith et al. 2001, Smith and Nichols 2004); and the structure of dense second-growth stands effectively renders prey unavailable to foraging goshawks (Beier and Drennan 1997). Avian communities in managed forests include few, if any, additional prey for northern goshawks (Smith et al. 2001). Thus, breeding pairs in managed landscapes of Southeast Alaska likely rely almost entirely on productive old-growth forests as foraging and nesting habitat. That breeding pairs in managed landscapes of Southeast Alaska depend on productive old-growth forests to meet life-history needs was reflected in the findings of compositional analyses and radiotelemetry studies, both of which determined that northern goshawks strongly selected medium- and high-volume old-growth forests and avoided recently managed or non-forested habitats (Iverson et al. 1996).

PLANNING AND MANAGEMENT IMPLICATIONS

Management guidelines for northern goshawks in the southwestern United States recommend active management of the entire planning area to regenerate forests as well as provide nesting and foraging habitat. Despite insufficient local information to prescribe the design of a reserve-based approach to sustain northern goshawks, a hierarchical system of habitat reserves became the cornerstone of the TLMP wildlife conservation strategy to sustain viable and well-distributed populations across Southeast Alaska. This was to a large part a result of having to consider the risk to viability of multiple species for which there was more theoretical or empirical evidence that habitat reserves would sustain viable populations. Because additional conservation measures were incorporated at multiple spatial scales in the 1997 TLMP to provide sufficient nesting and foraging habitat for northern goshawks, the conservation strategy for northern goshawks in southeastern Alaska became a composite of conservation measures superimposed on a conceptual framework developed for other vertebrate species of concern.

More importantly, the 1997 TLMP did not incorporate the concepts of nest area, post-fledging area, and foraging area habitat management that underpin the current paradigm of conservation planning to sustain viable populations of northern goshawks across a significant portion of its range. However, applying these concepts to temperate rainforests and to a planning area that differs markedly in natural history, forest type, landscape structure, and management history requires a thorough understanding of differences and similarities in goshawk behavior and ecology among regions. Still, managing for uncertainty and avoiding the risk of trending the population downward can be improved by using biological concepts applied elsewhere to sustain northern goshawk habitat and populations throughout southeastern Alaska. The nuances of local ecological variability and subsequent refinement of management guidelines can be uncovered with additional field study. Meanwhile, biologists and land managers may want to consider ecological consequences to northern goshawk populations (and associated ecological communities) of potential habitat deficiencies in managed landscapes across the region. Planners and managers may want to revisit assumptions that current standards and guidelines and other conservation measures provide sufficient breeding season habitat to sustain viable and widely distributed goshawk populations. In the interim, project planning and land use management can be used to increase the longer-term security of preferred habitat (e.g., deferred harvest) or improve (e.g., thinning) marginal or unsuitable habitat in managed landscapes, especially across the North Prince of Wales Island Biogeographic Province.

Conservation plans rely on setting aside essential habitat to assure viability of indigenous wildlife communities in intensively developed landscapes. More often than not, little local information exists upon which to develop a sound conceptual framework or identify effective conservation measures. Thus, land-use planning frequently relies on biological data from other regions or incorporates multiple assumptions, many of which lack an underlying empirical or theoretical foundation. Determining the effectiveness of a conservation strategy is a daunting task, requiring long-term habitat and wildlife population monitoring. However, shorter term evaluations are possible and desirable to scrutinize underlying assumptions, identify deficiencies, refine elements and procedures, and prevent irreparable negative effects, should a conservation plan depend on long-term monitoring.

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Appendix A. Percentage of relative frequency (%) classes of 4 land-use designations (LUD) and 4 cover types in 2 types of ecological areas encircling 136 northern goshawk (*Accipiter gentilis*) nest sites in Southeast Alaska, USA. The radius of the post-fledging area (PFA) is based on the average movement (1,600 m) and the radius of the broader landscape is based on the average use area (90% mononuclear probability polygon) of radiocollared adult female goshawks during the breeding season (Iverson et al. 1996).

Ecological areas	LUD composition (%)				Cover-type composition (%)			
Percentage categories	Development	NNF	Natural	OG	Habitat[a]	Low-volume old growth	Clearcut	Nonproductive forest
PFA								
0–5	46	75	52	71	1	46	68	1
6–25	5	4	9	7	18	47	29	13
26–50	7	4	15	6	51	7	3	47
51–75	7	13	4	8	23	0	0	33
76–90	4	1	2	1	7	0	0	6
>90	32	3	17	7	0	0	0	1
Total	100	100	100	100	100	100	100	100
Home range								
0–5	37	74	38	56	1	46	68	0
6–25	6	7	19	21	19	54	30	7
26–50	13	9	17	14	63	1	2	35
51–75	10	9	7	7	15	0	0	50
76–90	13	1	4	1	3	0	0	7
>90	21	1	15	1	0	0	0	0
Total	100	100	100	100	100	100	100	100

[a] Medium- or high-volume strata old-growth rainforest (Iverson et al. 1996).

Proposed Forest Plan Amendment Further Compromises Established Conservation Measures to sustain Viable Northern Goshawk Populations

Winston Paul Smith, Ph.D.
Principal Research Scientist, University of Alaska – Fairbanks
wsmith58@alaska.edu/907-209-2373

A fundamental aspect of successfully incorporating and applying relevant knowledge to a complex process is considering the source (and thus the credibility) of the information. As the member of the team of Pacific Northwest Research Station Scientists assigned to review and analyze all information used to address wildlife viability issues for the 1997 TLMP, I contributed directly to the initial conceptual framework and subsequent species-specific elements that became the 1997 TLMP Wildlife Conservation Strategy (WCS). Over the 15 years that followed, I designed and implemented experimental research testing fundamental, underlying assumptions of the TLMP Conservation Strategy and other conservation measures specific to several select wildlife species including Northern Goshawk. The findings of this research were presented at scientific conferences and published in numerous articles in national and international peer-reviewed journals. Therefore, I submit that the following comments represent a unique understanding and perspective reflecting both the direct knowledge and experience gained through developing the TLMP WCS and the extensive, comprehensive, credible science experience and knowledge gained through studying select indicator species of the coastal rainforest ecosystem of Southeast Alaska. Accompanying this document is my Curriculum Vitae, which details the relevant experience and scientific publications.

Forest Planning Fundamentals

Given the complex, interdependent relationship between the Wildlife Conservation Strategy (WCS) and other elements of the Tongass Land and Resources Management Plan (TLMP) designed to conserve wildlife viability (Iverson and Rene 1997), any effort to amend the 1997 Land and Resource Management Plan (USDA Forest Service 1997) without a comprehensive analysis of the conservation strategy is fundamentally flawed. This is particularly problematic when such changes propose to continue logging old-growth forests or undertakes timber harvests (as opposed to science-based habitat management) in conservation elements, such as buffers. Consider further the reality that the multiple elements included in the 1997 TLMP to sustain biological diversity across the planning area were designed in the spatially explicit context of specific prescriptions regarding ownership, land-use designations (LUD), watershed restrictions (e.g., total harvest thresholds), old-growth reserve designations, and future land management activities (e.g., thinning). That is, each part of the 1997 TLMP was inexorably linked to all other components, and thus a piecemeal effort to revise portions of the forest plan (i.e., amending one portion of the Forest Plan in isolation, ignoring implications to other components) without a comprehensive analysis of the remaining components not only raises uncertainty about the credibility of the revised portions of the forest plan, it compromises the integrity of those essential components (such as the

WCS) that were not adequately analyzed. Consider further that there is no credible science that supports the supposition that the 1997 Wildlife Conservation Strategy is working as intended. Moreover, recent credible science does not support inherent fundamental assumptions of the 1997 TLMP Conservation Strategy (Smith 2007, 2013, Smith et al. 2011).

Role of Science in Forest Planning

In 1997 a landmark publication established precedence and a new paradigm for using the best available science in developing the 1997 Tongass Forest Plan (Everest et al. 1997), which subsequently was applied generally across the Forest Service in the development, revision, or amendment of forest plans. An essential prerequisite of this approach is to review and consider the most current, available, credible science. An explicit expectation of this new paradigm is that the Forest Plan explicitly acknowledges when prescribed policy or management is not consistent with the best available science (Everest et al 1997). Yet, a review of the citations listed in the draft EIS reveals that much of the relevant science regarding northern flying squirrels has presumably not been considered, as it is not cited in the text. Also, some references cited in the text (example: Smith et al 2005, page 3-233; Flaherty et al. 2010, page 3-259) are not included or properly cited (Smith et al. 2011, page 3-259 refers to a different publication than Smith et al. 2011, page 3-487) in References. Needless to say, it is difficult (if not impossible) to fulfill the expectations of using the best science to guide the management of national forests if the best available science has not been properly researched, documented, or assimilated. Indeed, only 2 of my 19 relevant publications (see accompanying CV) are cited in the references of the Draft EIS (USDA Forest Service 2015). Where publications have been cited, it is not clear whether the Forest Service has selected policy or management consistent with the science, a stipulation of the new paradigm for developing forest plans (Everest et al 1997). In some instances, suggested mitigations will not resolve the deficiencies described in the referenced publication or the findings of the research were ignored, or the corresponding narratives were misleading with respect to the implications of the findings or the need for mitigation (Smith et al. 2011 on page 3-233, paragraph 2). In this example, the findings uncover specific deficiencies and uncertainties in the ability of the Tongass Wildlife Conservation Strategy to function as intended, with compelling, credible (i.e., published in peer-reviewed journals) scientific evidence contradicting assumptions to sustain northern flying squirrels (Smith et al. 2011), essential prey of northern goshawks (Smith 2007). Clearly, further logging of old-growth forest or timber harvest (as opposed to habitat management) in second-growth forest of conservation elements, (e.g., buffers) will increase the disparity between conditions supported by the best available science and management actions as well as increase the risk to wildlife viability, including goshawks.

Northern Goshawk Breeding Season Ecology and Habitat

The northern goshawk in Southeast Alaska received special consideration as a "sensitive species" in the revised forest plan (USDA Forest Service 1997:4–89), in part because of concerns over the viability of endemic Queen Charlotte goshawk (Iverson et al. 1996, Iverson and René 1997, U.S. Fish and Wildlife Service 2007). To manage northern goshawk habitat, three critical spatial components of the nesting home range have been characterized: nest area, post-fledging family area (PFA), and foraging area (Reynolds et al. 1992). Although the conceptual framework for managing goshawk habitat largely was developed for forests of the Southwestern Region of the U.S. Forest Service, it is expected that these concepts apply elsewhere because its life history is similar throughout its range in North America (Squires and Reynolds 1997). Management recommendations developed from research in northern Arizona have been adopted by the Forest Service in Arizona, New Mexico, and Utah (Smith 2013). Managing habitat according to this paradigm is based on the species' biology, ecology, and use of space, and included the ecology of its primary prey (Reynolds et al. 1992).

Elements of breeding home range. – Suitable nest area habitat is critical for successful reproduction of goshawks. Nest areas are used more than1 year and may be used intermittently for decades. Many goshawk pairs have multiple (2 - 8) nest areas (Reynolds et al. 1992). Previously occupied nest areas are important for maintaining breeding populations of goshawks because they contain the habitat elements suitable for nesting. Nest areas typically have unique vegetation structures, include multiple nests and nest trees in one or more forest stands and are associated with specific landform features. In coniferous forests of the Southwest, boundaries of nest areas are determined by observing the behavior of the breeding pair, movements and other behaviors of newly fledged young, and the locations of prey plucking areas and roosts (Reynolds et al. 1982). Size and shape of nest areas are influenced by topography and depend on the availability of suitable patches of dense, large trees (Reynolds 1983). Furthermore, it was recommended that the breeding home range of each goshawk pair should include at least 3 nest areas and at least 3 replacement nest areas (i.e., stands with vegetative structural and landform features of nest areas; Reynolds et al. 1992).

Post-fledging family areas (Reynolds et al. 1992) are portions of the breeding home range used by adults and juveniles during the period after young leave the nest until they are no longer dependent on the breeding pair for food. The <u>desired PFA</u> encircles the nesting area, may include a diversity of forest conditions, but largely <u>resembles the nest area</u> in vegetation structure (Reynolds et al. 1992). The desired PFA affords young goshawks cover from predators and foraging habitat with sufficient prey to sustain them as they develop hunting skills prior to dispersal. Desired forests within PFAs should have overstories with at least 50% canopy cover and well-developed herb and shrub understories, as well as key habitat features essential to the life histories of goshawk prey species (Reynolds et al. 1992). Desired PFAs in southwestern coniferous forests encompass 420 acres (not including the acres for suitable and replacement nest areas), the acreage of a circle drawn from a radius equal to the mean size of the 'female core area' that included her nest and the movements of juveniles before dispersing.

Foraging habitat. - Features of preferred foraging habitat are not well known because goshawk home ranges are large and varied in composition, and because this spatial and habitat component of goshawk home ranges has received the least amount of study (Reynolds et al. 1992). The desired foraging habitat will support an abundant and diverse community of prey species. For many forest biomes this often occurs within landscapes in which there is a mosaic of various seral stages, which provides habitat for multiple prey species requiring a wide range of forest conditions. Managing habitat in these forest biomes requires an uneven-aged silvicultural system, which produces a mosaic of different-aged stands that were selectively harvested and produce structurally complex vegetation profiles rather than regeneration harvest, such as clearcuts, that remove the entire canopy and result in a single, uniform and dense canopy for decades following harvest (Nowacki and Kramer 1997). Evidence from radio-telemetry studies in southeastern Alaska suggests goshawks prefer foraging in late-seral forest (Iverson et al. 1996). In Southeast Alaska, almost all prey species occur in late-seral forests (Smith 2013), but goshawk preference of older forests is likely related to vegetative structural features that affect its ability to maneuver and catch prey (Reynolds et al. 1992).

TLMP Conservation Strategy

The conservation strategy developed for northern goshawks in the 1997 TLMP was fundamentally flawed from the outset (Smith 2004, Smith 2013). The most obvious shortcoming was the dependence on a network of old-growth reserves and other old-growth set asides in a matrix of cumulative, intensive, regeneration harvest (i.e., clearcut logging) to provide sufficient breeding season habitat (Smith 2013). Although the network of old-growth reserves and old-growth set asides (i.e., Old Growth LUD, riparian buffers, shoreline buffers) provide substantial old-growth forest habitat across managed landscapes, the size and spatial configuration of OGRs and set asides were not designed to accommodate the hierarchical structure and spatial scale of northern goshawk breeding ranges (Reynolds et al. 1992, Iverson et al. 1996, Iverson and René 1997, Smith 2013). Furthermore, the assumption that there would be ample habitat with breeding pairs to sustain viable goshawk populations in non-developmental LUDs was not supported by an extensive systematic survey of breeding goshawks in wilderness and roadless areas of Southeast Alaska (Schempf et al. 1996, Smith 2013). Moreover, a network of old-growth reserves has never been implemented or developed as a conceptual framework to sustain viable populations of northern goshawks (Smith 2004, 2013, Reynolds et al. 1992, 2006). Indeed, the recommended paradigm for managing goshawk habitat on national forests in the southern portions of its range (where prey communities flourish in early seral forests) is active management of the entire landscape (Reynolds et al. 1992), albeit more selective and much less expansive than complete removal of the overstory across thousands of acres of clearcuts on POW and other targeted islands (USDA Forest Service 1992, Smith et al. 2011).

Standards and guidelines for forest management actions were established purportedly using important ecological aspects of this species' biology (Iverson et al. 1996, Iverson and René 1997). At the landscape scale, guidelines were included to limit the amount

(%) of logging that could occur in each watershed in select Biogeographic Provinces. Like many conservation measures (USDA Forest Service 1997: Appendix N), however, these guidelines were spatially inexplicit with respect to known goshawk breeding pairs or territories. That is, guidelines are generally applied across the planning area with little explicit consideration of special areas, needs, or landscape context. Not all watersheds are equal with regard to contributions to the habitat needs of goshawk breeding pairs. For example, watersheds near OGRs or other old-growth set asides may be more (or less) valuable than watersheds in a more heavily managed matrix. Regardless, conservation measures generally applied Tongass wide may or may not benefit targeted wildlife populations (Iverson and René 1997).

Some conservation measures were spatially explicit. For example, the standard and guidelines specific to goshawk reproduction stipulated that managers should “preserve nesting habitat [100 acres] around all confirmed and probable nest sites” (U.S. Forest Service 1997:4–89) and included several criteria for identifying nest sites and guidance related to achieving this objective. However, 100-acres around a nest tree does not provide sufficient nest and post-fledging area habitat in northern Arizona, where breeding ranges are smaller (Reynolds et al. 1992) than in Southeast Alaska (Iverson et al. 1996). Moreover, in managed landscapes the conservation strategy did not include guidelines to ensure the coincidence of OGRs or other old-growth set asides and nest tree buffers to achieve the necessary habitat to support a breeding pair (Smith 2013).

Synopsis of New Credible Science

There was little local science with which to develop the Tongass standards and guidelines and policy for managing habitat for northern goshawks in Southeast Alaska as most studies had been conducted elsewhere and information was largely unavailable (Iverson et al. 1996). Since 1997, however, considerable effort has yielded valuable empirical data about the life history, ecology, and habitat needs of northern goshawks in Southeast Alaska, especially during the breeding season (Smith 2013). Also, there have been numerous studies and reviews completed throughout its range (Boal et al. 2006, Morrison 2006). Moreover, reviews and studies in British Columbia have substantially increased our knowledge about goshawks in temperate rainforests (Doyle 2006).

In western North America, breeding home ranges of goshawks often are represented as a hierarchy of 3 areas, all of which need to be considered simultaneously in land-use planning or mitigation (Reynolds et al. 2006, Northern Goshawk *Accipiter gentilis laingi* Recovery Team 2008): 1) nest area, 2) post-fledging area (PFA), and 3) foraging area. Nest areas provide alternate nest trees, roost trees, prey plucking posts, and serve as centers of essential breeding behaviors or life-history events (Reynolds et al. 1992, 2006). PFAs surround active nest trees and represent the core-use area of an adult female and of young goshawks after fledging but before becoming independent of adults and dispersing. Moreover, the biological role of post-fledging areas and nest areas are similar and therefore it is useful to consider them as one functional component (Smith 2013). Regardless, the habitat composition (i.e., overstory) of post-

fledging areas should be similar to nest areas (Reynolds et al. 2008). Foraging areas comprise the majority of northern goshawk breeding home ranges and are especially important for adults providing food to young and for juveniles prior to natal dispersal. The most imminent threats to breeding populations are loss or fragmentation of nesting and foraging habitat, especially reductions in prey diversity and availability (Reynolds et al. 1992, 2006, 2008; Northern Goshawk *Accipiter gentilis laingi* Recovery Team 2008).

Spatially Explicit Analysis of Contributions of Conservation Strategy Toward Sustaining Northern Goshawk Habitat

Despite a substantial increase in knowledge since the revision of the 1997 Tongass Land and Resource Management Plan, the implications of those new insights to goshawk conservation and land-use policies in Southeast Alaska had not until recently been rigorously examined. In particular, it is unclear whether a system of old-growth reserves designed explicitly for other wildlife species plus protection of goshawk nest trees in landscapes intensively managed for timber (clearcut logging) would provide sufficient habitat to sustain breeding populations of the northern goshawk across the planning area (Smith 2013).

Smith (2013) conducted a spatially explicit analysis of habitat used and available to breeding pairs at 136 nests across the Tongass National Forest. Overall, 100% of the nest trees were in productive (low-, medium-, or high-volume) old-growth forests, which comprised 66.1% of goshawk nest areas. The remainder of nest areas was in scrub forests (fens), non-forested areas (muskegs), or regeneration stands following clearcut logging. A total of 58 nest areas primarily (more than 50%) consisted of high-volume old growth; 57 and 15 nest areas primarily consisted of medium- and low-volume old growth, respectively. Six nest areas did not contain any old-growth forest; according to notes in the database file, those nest trees were located in portions of the forest that were clearcut-logged after a breeding pair had selected a nest tree. If nest trees on clearcut sites or near a natural feature creating an abrupt forest edge (e.g., shoreline) were excluded (n = 11), mean proportion of productive old-growth forest in nest areas was 0.712. The mean proportions of volume strata in the remaining nest areas (n = 125) were 0.097, 0.283, and 0.289 for low-, medium-, and high-volume forests, respectively. Based on the habitat at 125 nest sites and within corresponding nest areas and on the findings of a previous habitat selection study (Iverson et al. 1996), Smith (2013) referred to medium- or high-volume old growth in virtual areas below as ‘choice habitat.’

Land-use Designation and Habitat Composition of Virtual Areas

The composition of land-use designations of an <u>average post-fledging area</u> contained a <u>relatively large proportion of Development</u> (land uses that modify landscapes) lands, with more than 30% of all nest areas having more than 91% of the post-fledging area as lands available for timber production (Fig. 1*a;* Appendix A Smith 2013). Cover-type composition of post-fledging areas contained a relatively large proportion of non-forest cover types (Fig. 1*b*; Smith 2013). About 30% of the nests had greater than 51% (i.e.,

51–75%, 76–90%, or greater than 90%) of the corresponding post-fledging area in medium- or high-volume old growth (choice habitat); 51% of nests had 26–50% of the post-fledging area in choice habitat. Most (60%) of this choice habitat was in the Development land-use designation or Non–National Forest designation (Fig. 1*a*, Smith 2013); 16% of the nests had more than 51% of the post-fledging area in the Old-Growth land-use designation, with the remainder in Natural Setting. Across all nest areas, the Old-Growth land-use designation averaged 14.8% (250 acres) of the total post-fledging area acreage. Development, Non–National Forest, and Natural Setting averaged 41.1% (690 acres), 13.5% (222 acres), and 27.2% (455 acres), respectively. Among cover types, choice habitat averaged 39.4% (655 acres) of the post-fledging area; low volume forest, clearcut, and non-forest lands averaged 8.3% (140 acres), 3.9% (65 acres), and 45.0% (655 acres), respectively.
Similar results were obtained from an analysis of the female breeding home range, but with 3 notable differences. The percentage of this broader landscape that consisted predominantly (more than 75%) of lands available for development was greater than in post-fledging areas (Fig. 2*a;* Appendix A Smith 2013). The percentage of the total area with 26–50% of the total area in choice habitat also increased in comparison with the post-fledging area, whereas about half as many nests had at least 51% of this broader landscape in choice habitat as compared with the post-fledging area (Fig. 2*b*, Smith 2013).

According to the conservation assessment (Iverson et al 1996), implementation of the 1997 Tongass Land and Resource Management Plan for 100 years would result in “a moderately high likelihood of providing the amount and distribution of habitats to sustain long-term well distributed viable populations of goshawks throughout the Tongass” (U.S. Forest Service 1997:appendix N38). This long-term projection, an inherent assumption of the conservation strategy, was based on analyses at multiple spatial scales (U.S. Forest Service 1997). This study by Smith (2013) used contributions of various elements of the conservation strategy to biological components of the breeding range centered on specific nest sites. This approach allowed an examination of the underlying assumption that the 1997 Tongass Land and Resource Management Plan provides habitat needed to sustain breeding populations of goshawks across the planning area. Productive old-growth forests unavailable for timber harvest were used frequently by northern goshawks and “thus the contribution of these habitats must be included in an assessment of overall risk to sustainability of goshawk habitat” (U.S. Forest Service 1997:appendix N38).

Standards and guidelines prescribed for protection of goshawk nest areas (40 ha) in Southeast Alaska are unlikely to meet breeding-season habitat objectives established for goshawk populations elsewhere (Reynolds et al. 1992). The expectation that, in landscapes managed intensively for timber products, habitat contributed by other elements of the Tongass conservation strategy (e.g., old-growth reserves) will mitigate this deficiency was not supported by Smith’s analysis. An ideal northern goshawk home range consists entirely of older forests with small, dispersed openings (Reynolds et al. 2006, 2008). Guidelines for the composition of post-fledging areas stipulate that “the majority (60%)” of a post-fledging area should be in forest of older age classes

(Reynolds et al. 1992:23), which continues to be corroborated by further study in other portions of this species' range, including temperate rainforests (Smith 2013). In the Smith (2013) study, nest areas averaged 71% productive old growth; 58% of the nest area consisted of medium- or high-volume old growth. Before logging, landscapes across Southeast Alaska likely were similar in composition to current nest areas (U.S. Forest Service 1997). At the time of this study, only about one-third of 136 virtual post-fledging areas contained more than 51% choice habitat. More importantly, the average composition of 'unsecure' (i.e., Development or Non–National Forest land-use designations) habitat was 55%, and 60% of all post-fledging areas consisted of more than 51% unsecure habitat. Regardless of whether you compare these results with guidelines from the southwestern United States (Reynolds et al 1992) or the habitat at nest sites and in nest areas of Southeast Alaska (i.e., desired future condition of goshawk post-fledging areas; Reynolds et al. 2008) recorded in this study, the observed composition of post-fledging areas was less than the minimum recommended or desired amount of habitat (Smith 2013).

This conclusion differs from a general forest-wide habitat availability assessment (i.e., not explicitly linked to specific goshawk nest sites) based on analyses at multiple spatial scales (U.S. Forest Service 1997:appendix N43). The disparity can be explained by differences in scale and biological relevance (i.e., linked to specific life-history needs; Reynolds et al. 2006) of analyses between this study and previous analyses (Iverson et al. 1996, U.S. Forest Service 1997:appendix N38). Some of the analyses cited in the summary appraisal were at a regional scale (forest-wide) and spatially inexplicit. For example, the conclusion that 95% of the northern goshawk range in the region has a high likelihood of sustaining habitat because 93% of the forests would have less than 47% of productive old-growth harvested over the planning horizon provides little spatially explicit information about breeding-season habitat, especially for populations occurring on islands. Also, results of stand-level analyses cited in the summary largely focused on aspects of forest management that were not immediately relevant to the life-history needs of breeding pairs. Conclusions that only a small percentage of nest areas examined had experienced any logging or that only a small proportion of nest areas were harvested says little about breeding-season habitat or resources available to breeding pairs, especially across the broader landscape. Intermediate-scale analyses and protective measures, such as limiting total harvest to no more than 33% of a watershed during the planning horizon (effectively a 300-yr rotation), are spatially explicit and potentially have biological relevance (i.e., approximate size of goshawk home ranges). However, management guidelines not explicitly coupled to northern goshawk breeding ranges or life history are at risk of not meeting habitat needs of individual breeding pairs (Reynolds et al. 2006, Northern Goshawk *Accipiter gentilis laingi* Recovery Team 2008).

At the time of the summary assessment (U.S. Forest Service 1997), about 5% (35/678) of the watersheds exceeded the stipulated threshold of total harvest, with 33–47% of the total available productive old-growth forests already harvested; 26 of those (74%) were concentrated in one Biogeographic Province (North Prince of Wales Island). Further logging on POW or in other portions of the Tongass where watersheds already

exceed these thresholds will increase the disparity between existing harvests and threshold guidelines and increase the number of watersheds that exceed the threshold. The assessment acknowledged the higher risks of exceeding watershed thresholds of total harvest, especially across North Prince of Wales Island, but assumed that large reserves in those landscapes would mitigate the habitat loss from excessive timber harvest. The findings of this study clearly demonstrate that contributions of old-growth reserves and other conservation elements (e.g., riparian or shoreline buffers) might not mitigate the cumulative habitat loss in intensively managed landscapes. This conclusion is supported by evidence on nearby islands that extensive loss and fragmentation of habitat from clearcut logging contributed to population declines of Queen Charlotte goshawks (Doyle 2006).

The findings of these analyses increase uncertainty that northern goshawk breeding-season habitat objectives are being met in managed landscapes of Southeast Alaska. Two lines of reasoning support this conclusion. First, spatially explicit analyses of contributions to northern goshawk breeding-season habitat revealed that conservation measures of the Tongass Land and Resource Management Plan contribute about <u>half</u> the <u>secure</u> habitat recommended for post-fledging areas of breeding pairs in the southern portion of this species range (Reynolds et al. 1992) and was <u>less</u> than <u>half</u> the relative amount of habitat documented in nest areas in Southeast Alaska. A similar conclusion was obtained for the broader landscape (21 km^2) that surrounded each nest. This is because much of the habitat across the landscape has been clearcut-logged and <u>half</u> the remaining choice habitat is in the Development land-use designation available for timber harvest. The potential for second-growth stands to become useable habitat over the Tongass planning horizon is limited because unmanaged second growth typically requires at least 300 years following disturbance to develop old-forest features (Nowacki and Kramer 1998). Appropriate (science-based) active management targeting habitat improvement can hasten the development of old-forest condition, but pre- and commercial thinning has occurred in only about 30% of 267,000 ha that have been harvested across the region (USDA Forest Service 2003).

Secondly, guidelines developed for northern goshawk populations in the southwestern United States may underestimate habitat needed by breeding pairs in Southeast Alaska. A critical consideration in conserving habitat to support breeding populations is sufficient habitat to sustain prey resources (Reynolds et al. 2006). Despite possible differences in life history or ecology across the range of northern goshawks, the nesting and foraging habitat of successful breeding pairs must support adequate prey populations. In Southeast Alaska, the predominant (frequency and biomass) prey items during the breeding season (Lewis et al. 2006) are bird and mammal species that are most abundant, or occur exclusively, in productive old-growth forests (Iverson et al. 1996,Smith et al. 2001, 2004, 2005). Consider further that the mammal fauna of Southeast Alaska is depauperate (Smith 2005); few mammal species exclusively occur in low-volume or managed forests of Southeast Alaska (Smith et al. 2001, Smith and Nichols 2004); and the structure of dense second-growth stands effectively renders prey unavailable to foraging goshawks (Reynolds et al 1992, 2006). Avian communities in managed forests include few, if any, additional prey for northern goshawks (Smith et al.

2001). Thus, breeding pairs in managed landscapes of Southeast Alaska likely rely almost entirely on productive old-growth forests as foraging and nesting habitat. That breeding pairs in managed landscapes of Southeast Alaska depend on productive old-growth forests to meet life-history needs was reflected in the findings of compositional analyses and radio-telemetry studies, both of which determined that northern goshawks strongly selected medium- and high-volume old-growth forests, and avoided recently managed or non-forested habitats (Iverson et al. 1996).

Summary and Conclusions

Management guidelines for northern goshawks in other portions of its range in the United States do not include a network of old-growth reserves in intensively managed landscapes. Rather, in other forest biomes where prey communities also occur in early seral forests, a mixture of even- and uneven-aged silvicultural prescriptions are used such that the landscapes are a mosaic of different aged stands, predominated by mature forests to provides ample nest area and post-fledging are habitat. Despite insufficient local information to prescribe the design of a reserve-based approach to sustain northern goshawks, a hierarchical system of habitat reserves became the cornerstone of the TLMP wildlife conservation strategy to sustain viable and well-distributed populations across Southeast Alaska. This was to a large part a result of having to consider the risk to viability of multiple species for which there was more theoretical or empirical evidence that habitat reserves would sustain viable populations. Because additional conservation measures were incorporated at multiple spatial scales in the 1997 TLMP to provide sufficient nesting and foraging habitat for northern goshawks, the conservation strategy for northern goshawks in southeastern Alaska became a composite of conservation measures superimposed on a conceptual framework developed for other vertebrate species of concern.

More importantly, the 1997 TLMP did not incorporate the concepts of nest area, post-fledging area, and foraging area habitat management that underpin the current paradigm of conservation planning to sustain viable populations of northern goshawks across a significant portion of its range. Managing for uncertainty and avoiding the risk of trending the population downward can be improved by using biological concepts applied elsewhere to sustain northern goshawk habitat and populations throughout southeastern Alaska. The nuances of local ecological variability and subsequent refinement of management guidelines can be uncovered with additional field study. Meanwhile, biologists and land managers are prudent to consider ecological consequences to northern goshawk populations (and ecological communities) of potential habitat deficiencies in managed landscapes across the region.

Specifically, planners and managers may want to revisit assumptions that current standards and guidelines and other conservation measures provide sufficient breeding season habitat to sustain viable and widely distributed goshawk populations. In the interim, project planning and land use management can be used to increase the longer-term security of preferred habitat (e.g., deferred harvest) by preventing any further

harvest of old-growth forest, especially in watersheds that approach or exceed established thresholds. Further loss of old-growth forests or inappropriate management of second-growth stands (i.e., timber harvest rather than science-based habitat management), especially in existing riparian buffers or other conservation elements, will increase the risk to viability of northern goshawks in multiple ways: reduce nesting habitat; reduce post-fledging area habitat, reduce foraging habitat and reduce prey species on which breeding pairs depend, most notably red squirrels, flying squirrels, blue or spruce grouse, and jay and crow populations. Alternatively, science based thinning of second-growth stands can hasten second growth toward breeding habitat and will benefit goshawks directly and indirectly. Therefore, any forest plan amendment or revision that proposes to continue the harvest of old-growth forest or impose clearcuts in buffers or other conservation elements without including a comprehensive analysis of the Wildlife Conservation Strategy is imprudent and irresponsible as it ignores the best available credible science.

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THE NORTHERN FLYING SQUIRREL AS AN INDICATOR SPECIES OF TEMPERATE RAIN FOREST: TEST OF AN HYPOTHESIS

WINSTON P. SMITH,[1] SCOTT M. GENDE,[2] AND JEFFREY V. NICHOLS[3]

U.S. Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 2770 Sherwood Lane, Suite 2A, Juneau, Alaska 99801-8545 USA

Abstract. Management indicator species (MIS) often are selected because their life history and demographics are thought to reflect a suite of ecosystem conditions that are too difficult or costly to measure directly. The northern flying squirrel (*Glaucomys sabrinus*) has been proposed as an MIS of temperate rain forest of southeastern Alaska based on previous studies in the Pacific Northwest that demonstrated its habitat is multi-factorial, i.e., an emergent property of old-growth forest. We evaluated the suitability of flying squirrels as MIS in temperate rain forests of Alaska by modeling seasonal (spring, autumn) microhabitat use with stepwise logistic regression (SLR) using either individual habitat variables ($n = 26$) or multivariate habitat ''factors,'' which were linear combinations of individual habitat variables generated from factor analysis. We compared the efficacy of single variable vs. multivariate factor models in explaining variation in microhabitat use to test the hypothesis that the habitat of flying squirrels in southeastern Alaska was an emergent property of old-growth rain forest. The underlying premise was that if factors were more thorough in explaining microhabitat use, the habitat of flying squirrels was multifactorial; that is, it consisted of multiple late-seral forest attributes occurring coincidentally at usable spatial scales (e.g., home range). SLR models with multivariate factors performed poorer in predicting capture sites than models of individual habitat variables. Two variables, density of large (>74 cm dbh) trees and understory cover of *Vaccinium*, explained much of the variation in microhabitat use. We conclude that the habitat of *G. sabrinus* in southeastern Alaska does not reflect emergent properties of old-growth forest in southeastern Alaska and hypothesize that this pattern may be related to regional ecological differences that facilitate a more general lifestyle than populations in the Pacific Northwest. Furthermore, the effectiveness of *Glaucomys sabrinus* as an MIS in north temperate rain forest is suspect, illustrating that regional differences in ecology of a species warrant caution when considering the suitability of MIS among geographic areas.

Key words: density; Glaucomys sabrinus griseifrons; *logistic regression; microhabitat use; northern flying squirrel; old growth; southeastern Alaska; temperate rain forest.*

INTRODUCTION

Whether land management planning (e.g., habitat conservation plans; Loehle et al. 2002) will facilitate a long-term goal of maintaining biological diversity is foremost among many issues challenging forest managers today (Szaro and Johnston 1996). The recent shift from single-species management toward consideration of ecological communities signifies an increasing appreciation for maintaining functional relationships and processes in forested ecosystems (Carey and Curtis 1996, Willson 1996, Williams et al. 2002). However, the value of species with unique life histories and ecological attributes, or significant community relationships, should not be ignored (Carey 1991, 1995, Schmitz et al. 2000, Soulé et al. 2003). Some species have relatively complex life histories and their habitat is multi-factorial; their presence indicates the presence of complex habitat conditions, such as old-growth forests (Carey et al. 1999, Carey 2000*a*). Others have evolved keystone roles linked to fundamental processes (Maser et al. 1978, Willson et al. 1998). Equally important are interspecific relationships, such as competitive (e.g., Smith 1981) or predator–prey interactions (e.g., Carey et al. 1992, Soulé et al. 2003). Cascading effects to vertebrate assemblages of losing species that play keystone roles or have complex life histories can be substantial, including a reduction of ecosystem stability or resiliency through a loss of additional species or diminished ecosystem function (Borrvall et al. 2000, Schmitz et al. 2000).

Regardless of whether the focus is ecosystem processes or multi-species relationships within communities, challenges of managing forest ecosystems are intensified by the fact that many vertebrates of late-seral forests are habitat or trophic specialists and thus

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[1] E-mail: WinstonSmith@fs.fed.us

[2] Present address: National Park Service, Glacier Bay Field Station, 3100 National Park Road, Juneau, Alaska 99801 USA.

[3] Present address: Alaska Department of Fish and Game, Division of Sport Fish, Southeast Regional Office, P.O. Box 240020, Douglas, Alaska 99824 USA.

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are sensitive to cumulative disturbance (Carey 1991, 1995, Laurance 1991, Patton 1992, Lomolino and Perault 2000). Nowhere has the challenge of sustainable management of multiple forest values been more evident recently than in landscapes of western North America, especially the Pacific Northwest, where several wildlife species apparently achieve their highest densities in old-growth coniferous forests (Forsman et al. 1984, Carey 1989, Huff et al. 1992). Extensive modification of old-growth forests has generated much concern over biological diversity (Szaro and Johnston 1996, Carey 1998, 2000*a*, *b*), especially the viability of late-seral habitat specialists (Forest Ecosystem Management Assessment Team 1993, Everest et al. 1997). Add to this the practical challenges and less than stellar accomplishments of single-species management, and the prospect of maintaining biological diversity in managed forests is disappointing (Simberloff 1998).

Ecosystem management recently emerged as a broad-scale ecological paradigm for maintaining biological diversity across federal (Rauscher 1999) and many industrial forests (Loehle et al. 2002), largely because of both theoretical and empirical strengths over managing single species (Simberloff 1998). However, there are many practical challenges to maintaining the ecological and functional integrity of entire watersheds, not the least of which is monitoring a myriad of ecosystem elements and processes (Landres et al. 1988, Niemi et al. 1997, Simberloff 1998). Because monitoring ecosystems is problematical, managers have selected surrogates, most notably ''indicator'' species, to assess environmental conditions or evaluate the response of forest ecosystems to external perturbations (Simberloff 1998). The concept of indicator species is not novel (Hall and Grinnell 1919), but its prominence in natural resource management emerged during the mid-1970s and mid-1980s, when its application became formally integrated into procedures used by the USDI Fish and Wildlife Service (U.S. Department of Interior 1980) and USDA Forest Service. Regulations pursuant to the National Forest Management Act of 1976 (Code of Federal Regulations 1985) require that National Forests incorporate management indicator species (MIS) in effects analyses of management plan alternatives during forest planning (e.g., Tongass National Forest; Everest et al. 1997).

Criteria for selecting MIS may vary according to management goals, but typically species whose populations are thought to reflect the ''health'' of an ecosystem are primary candidates (Landres et al. 1988, Simberloff 1998). In practical terms, ecosystem health represents a myriad of habitat attributes and processes, which often are too difficult or costly to measure. Accordingly, species with complex life histories are good MIS candidates, particularly in forest ecosystems, because healthy populations of these taxa are thought to indicate that many facets of ecosystem condition exist (Carey 2000*a*).

The northern flying squirrel (*Glaucomys sabrinus*) has been proposed as an MIS for north temperate rain forests because its populations become increasingly abundant with increasing forest complexity (horizontal and vertical heterogeneity in vegetation and structural features) in the Pacific Northwest (Carey et al. 1999, Carey 2001) and elsewhere (Weigl et al. 1992). Densities of flying squirrels were more abundant in old-growth and complex young forests than conventionally managed stands in a variety of coniferous forests across the Pacific Northwest (Carey et al. 1992, Carey 1995, Waters and Zabel 1995, Witt 1992; but see Rosenberg and Anthony 1992, Ransome and Sullivan 2003). Its life history reputedly is linked to numerous attributes of old forest (Carey 1989, 1995, Carey et al. 1992, Waters and Zabel 1995, Witt 1992).

In the Pacific Northwest, *G. sabrinus* density and microhabitat use have been correlated with vegetative and structural attributes that are common among forest types across several locations (Carey et al. 1999). However, no single habitat variable or group of habitat attributes thoroughly explained variation across geographic areas. Rather, the relationship between habitat and flying squirrel abundance appears to be multifactorial—a consequence of increasing synergism among habitat elements as forests develop and additional key habitat elements coincide at spatial scales that facilitate inclusion within a flying squirrel's home range (Carey et al. 1999, Carey 2000*a*). Habitat conditions that consistently explained variation in squirrel activity (i.e., captures) within stands, and differences in abundance among stands, were forest attributes such as ''decadence'' (prevalence of dying, dead, or decaying trees), which were habitat ''factors'' that incorporated unique ecological information from multiple variables (Carey et al. 1999:54).

In southeastern Alaska, temperate coniferous rain forests have many structural attributes that reflect the coastal coniferous forests of the Pacific Northwest (e.g., large trees and snags, coarse woody debris; Carey et al. 1999) and are similar in plant composition. *Glaucomys sabrinus* is one of two arboreal rodents that occur throughout most of the region (MacDonald and Cook 1996), and its life history was believed to be similar to populations in the Pacific Northwest (Suring 1993). Mean densities of flying squirrels are comparable to (or higher than) those reported for mesic or wet coniferous forests of California, Washington, and Oregon (Smith et al. 2003, Smith and Nichols 2003), but little is known about its habitat relations in southeastern Alaska, particularly correlates of microhabitat use and density (Bakker and Hastings 2002, Smith et al. 2004). A thorough understanding of the demography and habitat relations of *G. sabrinus* is fundamental to determining its suitability as an MIS of temperate rain forests (Carey et al. 1999, Carey 2000*a*, Jorgensen 2002, Morris 2003, Simberloff 1998).

The purpose of this study was to evaluate the suitability of *G. sabrinus* as an MIS of temperate rain forest through a quantitative analysis of its habitat relations in southeastern Alaska. Specifically, we asked whether the habitat of *G. sabrinus* in southeastern Alaska was an emergent property of old-growth rain forests by comparing the efficacy of models developed from individual variables vs. multivariate factors to test the hypothesis that its habitat is multifactorial (Carey et al. 1999). If the optimal habitat of *G. sabrinus* is multifactorial, then multivariate habitat factors should more thoroughly explain variation in microhabitat use than individual habitat variables (Carey 2000*a*).

Methods

Study area

Southeastern Alaska has a cool, wet (200–600 cm precipitation) maritime climate with mean monthly temperatures ranging from 13°C in July to 1°C in January (Searby 1968). The region is unique with numerous naturally fragmented landscapes, a dynamic geological history (MacDonald and Cook 1996), and coastal temperate coniferous rain forest (Alaback 1982, Harris and Farr 1974). The rain forest is distributed among islands of the Alexander Archipelago or isolated along the narrow mainland by mountains and ice fields. Topography, geology, climate, and other environmental features create a variety of isolated habitats; spatial heterogeneity occurs at multiple spatial scales in a manner rarely found elsewhere. Fragmentation of natural forest habitats has increased markedly since the middle of the 20th century because of land use; most notably from extensive clearcut logging (50% of low elevation, old-growth forest on some islands) throughout the region (USDA Forest Service 1997, Smith and Nichols 2003).

We studied populations of *Glaucomys sabrinus griseifrons* in the north-central region of Prince of Wales Island (55°42′–55°48′ N, 132°47′–132°52′ W; Smith and Nichols 2003) in the two dominant forest habitats: upland old-growth (upland–OG) and peatland–scrub/mixed-conifer forests (peatland–MC). Upland old growth is represented by several plant associations of western hemlock (*Tsuga heterophylla*)–Sitka spruce (*Picea sitchensis*) forests (DeMeo et al. 1992) and to a lesser extent red cedar (*Thuja plicata*) and yellow cedar (*Chamaecyparis nootkatensis*). The *Tsuga–Picea* forest type (upland–OG) constitutes most of the closed-canopy forests in the region (Alaback 1982). Upland–OG stands are highly productive forests that support high volumes (>400 m^3/ha) of timber with a closed canopy of tall (>60 m), large (≤2.5 m diameter) trees, and a mostly herbaceous understory (Harris and Farr 1974, Alaback 1982, DeMeo et al. 1992). It is spatially heterogeneous at a scale of <1 ha (Schoen et al. 1984) and usually occurs on low elevation, well-drained sites, frequently as a mosaic with muskegs (Neiland 1971). Overstory dominants include Sitka spruce and western hemlock. Dense patches of blueberry (*Vaccinium* spp.) typically dominate the understory. These sites have an uneven-aged, multi-layered overstory, dominant trees generally >300 years old, and extensive structurally diverse understories (Ver Hoef et al. 1988, Hanley and Brady 1997).

Peatland–MC habitat differs markedly from upland–OG in many ways, not the least of which is the patchiness of dense forest canopy cover, which is a consequent of highly varied soil composition and moisture gradient (Neiland 1971). It is additionally heterogeneous at a scale of tens of meters, a complex of open to sparsely-canopied muskegs intermixed with patches of mixed-conifer vegetation that occur on gently sloping, elevated accretions of better drained, mineral soil (Neiland 1971, DeMeo et al. 1992). Conifer vegetation includes yellow cedar, red cedar, western hemlock, mountain hemlock (*Tsuga mertensiana*), and shore pine (*Pinus contorta* var. *contorta*). Understory vegetation varies considerably. Open areas with little overstory typically are comprised of a mixture of herbaceous and woody species, including sedges, grasses, skunk cabbage (*Lysichitum americanum*), and Labrador tea (*Ledum glandulosum*); blueberry dominates areas with well-developed overstories.

These forest habitats overlapped appreciably in plant composition and structural features, but differed substantially in intermediate scale (<100 m) spatial heterogeneity, especially with respect to amount and distribution of large live and dead trees, coarse woody debris, woody shrubs, and canopy closure. We chose these habitats because they represent end points of a natural continuum of forest cover and productivity, and reflect the range of conditions in temperate rain forest of southeastern Alaska.

Sampling flying squirrels and habitat variables

A more thorough description of our study sites on Prince of Wales Island, southeastern Alaska, and trapping protocols can be found in Smith and Nichols (2003). Each habitat replicate was a 13-ha grid with a 10 × 10 array of trap stations spaced at 40-m intervals. Two live traps were placed at each of 100 stations: one was attached at a height of 1.5 m to the bole of the largest tree within 5 m of the grid station, and a second was placed on or near the ground (e.g., on a log) within 2 m of the tree supporting the other trap. We trapped each site once during early spring (March–April) and once during early autumn (September–October) during 1998–2000 because we wanted density estimates from periods during the year when populations were expected to be at their lowest (i.e., immediately following winter) and when population levels were expected to be at their highest (i.e., weaning has occurred but juveniles had not dispersed; Carey 1991, Villa et al. 1999). During a trapping session, grids usually were operated for 14 days, an initial 6-day marking period,

TABLE 1. Habitat features measured within study grids where trap stations were centers of a 20-m circular plot in upland old-growth western hemlock (*Tsuga heterophylla*)–Sitka spruce (*Picea sitchensis*) forests and peatland–scrub/mixed-conifer forests, Prince of Wales Island, southeastern Alaska, 1999–2000.

Habitat variable	Description
Vacc1	percent cover of *Vaccinium* ≤0.3 m tall
Vacc4.5	percent cover of *Vaccinium* between 0.3 m and 1.5 m tall
Decid1	percent cover of deciduous shrubs (except *Vaccinium*) ≤0.3 m tall
Decid4.5	percent cover of deciduous shrubs (except *Vaccinium*) between 0.3 m and 1.5 m tall
Conifer1	percent cover of conifer seedlings ≤0.3 m tall
Conifer4.5	percent cover of conifer saplings between 0.3 m and 1.5 m tall
Moss	percent cover of moss
Herb	percent cover of herbaceous vegetation ≤1.5 m tall
Wood	percent cover of downed wood ≥1 m long and <25 cm midpoint diameter
Water	percent cover of surface water
Decay I	volume $(m^3)/m^2$ of downed wood ≥10 cm midpoint diameter and ≥1 m long in decay class I†
Decay II	volume $(m^3)/m^2$ of downed wood ≥10 cm midpoint diameter and ≥1 m long in decay class II†
Decay III	volume $(m^3)/m^2$ of downed wood ≥10 cm midpoint diameter and ≥1 m long in decay class III†
Decay IV	volume $(m^3)/m^2$ of downed wood ≥10 cm midpoint diameter and ≥1 m long in decay class IV†
Decay V	volume $(m^3)/m^2$ of downed wood ≥10 cm midpoint diameter and ≥1 m long in decay class V†
Stumps	density of stumps
Tree74	density of trees >1.5 m tall and >74 cm dbh
Tree50–74	density of trees >1.5 m tall and 50–74 cm dbh
Tree10–49	density of trees >1.5 m tall and 10–49 cm dbh
Tree5–10	density of trees >1.5 m tall and 5–10 cm dbh
Soft snag74	density of snags >1.5 m tall and >74 cm dbh with <2% of limbs ≥30 cm remaining
Soft snag50–74	density of snags >1.5 m tall and 50–74 cm dbh with <2% of limbs ≥30 cm remaining
Soft snag10–49	density of snags >1.5 m tall and 10–49 cm dbh with <2% of limbs ≥30 cm remaining
Hard snag74	density of snags >1.5 m tall and >74 cm dbh with ≥2% of limbs ≥30 cm remaining
Hard snag50–74	density of snags >1.5 m tall and 50–74 cm dbh with ≥2% of limbs ≥30 cm remaining
Hard snag10–49	density of snags >1.5 m tall and 10–49 cm dbh with ≥2% of limbs ≥30 cm remaining

Notes: Stumps are defined as the bases of topped-off dead trees between 0.3 m and 5 m tall; snags are standing dead trees >1.5 m tall.

† Decay classes according to Fogel et al. (1973), as modified by Sollins (1982).

a two-day period when traps were closed to allow animals to recover from trap-related stress, and another six-day recapture period.

We measured 26 vegetative and structural variables at trap stations where squirrels were captured and at every third trap station without a capture (Rosenberg and Anthony 1992, Carey et al. 1999, Smith et al. 2004). Variables included understory vegetation, midstory and overstory composition and structure, and volume and decay class (Fogel et al. 1973, Sollins 1982) of downed wood (See Table 1 for a description of variables and acronyms). Understory variables were estimated (percentage cover) in 1 × 1 m subplots placed at trap stations and at distances of 4 and 7 m from trap stations in the four cardinal directions (nine subplots per station). Mean values of the nine subplots were used to describe the understory at each trap station.

Statistical analysis and habitat modeling

Previously (Smith et al. 2004), we used stepwise logistic regression (SLR) to develop explanatory models to relate individual habitat variables to flying squirrel captures among 600 trap stations (six 10 × 10 grids, i.e., three replicates each of upland–OG and peatland–MC habitats). Trap stations were categorized as either having captured a squirrel (realized habitat) or not (unrealized habitat; Carey et al. 1999). A dichotomous response was used because of anticipated problems with model convergence when the likelihood of capturing an animal is greatly skewed toward a single response level (e.g., zero captures; Stokes et al. 1995); and because there was little ecological justification for delineating distinct categories for multiple captures, especially differentiating between microsites with one vs. two captures (Smith et al. 2004).

SLR models of habitat variables allowed us to examine correlates of habitat use relative to individual vegetative and structural characteristics. Here we expand on that analysis by comparing those results with SLR models of habitat ''factors,'' which are independent linear combinations of individual habitat variables generated from factor analysis. We used factor analysis to generate multivariate habitat factors (Carey et al. 1999) from the 26 measured vegetative and structural variables (Table 1). Factor analysis uses predictive data (i.e., 26 variables) and creates ''factors'' using correlation matrices. The first factor accounts for a certain amount of the variance in the original variables, whereas the second is created based on the highest correlation to the original variables after accounting for variation explained by the first factor, and so on. We used VARIMAX rotation within PROC FACTOR (SAS Institute

TABLE 2. Stepwise logistic regression models of habitat variables correlated with flying squirrel (*Glaucomys sabrinus griseifrons*) microhabitat use in peatland–scrub/mixed-conifer (peatland–MC) and old-growth western hemlock/Sitka spruce rain forest (upland–OG) during spring and autumn 1998–2000, Prince of Wales Island.

Model	Variable	Chi-square test (*P*)	Parameter estimate (1 SE)	Odds ratio† (95% CI)	Model goodness of fit‡ (*P*)
Spring					
Peatland–MC	Vacc4.5	0.001	0.035 (0.01)	1.4 (1.1–1.8)	0.23
	Tree74	0.007	0.098 (0.04)	2.7 (1.3–6.8)	
Upland–OG	Water	0.005	−0.087 (0.04)	0.4 (0.2–0.8)	0.60
Autumn					
Peatland–MC	Tree74	0.003	0.283 (0.12)	16.9 (2.8–615.5)	0.85
	Vacc1	0.029	0.064 (0.03)	1.9 (1.1–3.5)	
Upland–OG	Herb	0.013	−0.040 (0.02)	0.7 (0.5–1.0)	0.30
	Soft10–49	0.034	0.017 (0.01)	1.2 (1.1–1.4)	
	Tree10–49	0.014	−0.003 (0.01)	1.0 (0.9–1.0)	
	Hard50–74	0.045	0.083 (0.04)	2.3 (1.1–5.7)	

Notes: Data are from Smith et al. (2004). See Table 1 for a description of habitat variables.

† Effect of a 10-unit increase in the value of the variable (e.g., percent cover) on the probability of capture (SAS Institute 2000).

‡ Results of Hosmer and Lemeshow test (SAS Institute 2000), reported as the probability (*P*) that the model will be improved by an additional habitat variable.

2000) to rotate factors to obtain new uncorrelated (orthogonal) variables, and visual inspection of ''scree plots'' to identify factors used in subsequent modeling efforts (Cody and Smith 1997:257). Factor loadings (correlation of a factor with the 26 variables) provided insights into ecological interpretation of orthogonal habitat factors. Coefficients from a correlation matrix were used to determine the extent to which habitat variables were potentially redundant in explaining variation in the response variable because of multicollinearity among habitat variables (i.e., highly correlated; Zar 1999). This information was used to develop models through an evaluation of variable selection in SLR and an interpretation of factor loadings following factor analysis.

SLR models of microhabitat use were developed for both habitats during two seasons from individual variables and from multivariate habitat factors. Individual variables or factors were entered into a model if the $P \leq 0.25$, but were retained only if $P \leq 0.05$. For each correlate in the final logistic regression models, we computed confidence intervals on the odds ratios, which were based on the profile likelihood (Stokes et al. 1995, SAS Institute 2000). Thus, odds-ratio estimates were interpreted as the odds of capturing a flying squirrel given a specified unit increase or decrease in the habitat parameter (e.g., density of trees per ha) after being adjusted for the effects of other habitat elements in the model.

If the life history of northern flying squirrels is complex and linked to multiple old forest features (and thus a suitable management indicator species), we expected the SLR models with multivariate factors to perform better in predicting microhabitat use than models with individual habitat variables. To compare the efficacy of models developed from individual variables vs. multivariate factors, we quantified their performance in predicting captures among trap stations. We used prior probabilities (i.e., proportion of traps that captured squirrels) for each habitat × season combination to generate classification tables within PROC LOGISTIC. We compared the success rate of variable vs. factor-based models in correctly predicting capture sites, non-capture sites, and all trap stations. We used the Hosmer and Lemeshow test to evaluate the suitability of models derived using variables vs. factors, and examined several measures of goodness-of-fit (e.g., *C* statistic, R^2) to evaluate the association of predicted probabilities and observed responses (SAS Institute 2000).

RESULTS

Logistic regression: habitat variables

Four (i.e., two habitats × two seasons) significant logistic regression models of microhabitat use were produced from individual variables (Table 2). The models varied between habitats, and between seasons within habitats, in number and type of habitat variables. Density of large (>74 cm dbh) live trees was a significant variable in both spring and autumn models of peatland–mixed conifer (MC). The ecological impact of varying density of large trees on habitat use was substantial, especially during autumn when increasing the mean value of the predictor variable by 10 trees/ha (from a mean of 2 trees/ha to 12 trees/ha in peatland–MC) increased the odds of capturing a squirrel by a factor of 17. In upland–old-growth (OG), water was the only significant variable during spring and it was inversely related to the likelihood of capturing a squirrel. According to the odds ratio, an increase in mean percent surface water of 10% reduced the odds of capturing a squirrel by a factor of 2.5 (1.0/0.4). The autumn

TABLE 3. Multivariate factors and factor loadings (≥0.40) generated with factor analysis (SAS 2000) from 26 habitat variables measured in peatland–scrub/mixed-conifer (peatland–MC) and old-growth western hemlock/Sitka spruce rain forest (upland–OG) during 1999–2000, Prince of Wales Island.

	Peatland–scrub/ mixed conifer		Old-growth western hemlock/Sitka spruce	
Factor	Variable	Loading	Variable	Loading
1	Vacc4.5	0.761	Tree5–10	0.675
	Herb	−0.744	Tree10–49	0.664
	Tree10–49	0.645	Hard10–49	0.411
	Water	−0.615	Soft10–49	0.410
	Soft10–49	0.581		
	Vacc1	0.573		
	Stump	0.534		
	Moss	0.524		
	Decid4.5	−0.468		
	Hard10–49	−0.417		
2	Decay V	0.622	Wood	0.687
	Tree74	0.607	Moss	−0.602
	Decid1	−0.574	Vacc4.5	−0.503
	Tree50–74	0.567		
	Soft50–74	0.523		
	Hard74	0.445		
	Conif1	−0.416		
3			Herb	−0.507
			Vacc1	0.499
			Water	−0.480
			Decid4.5	−0.416
			Vacc4.5	0.409

Note: See Table 1 for a description of habitat variables.

upland–OG model included four habitat variables, but only density of hard snags 50–74 cm dbh and herb cover had notable ecological effects on microhabitat use. Squirrel captures were positively correlated with density of hard snags, whereas the odds of capturing a squirrel decreased with increasing herb cover (Table 2).

Logistic regression: multivariate habitat factors

Factor analysis produced two factors for peatland–MC and three factors for upland–OG (Table 3). Three significant SLR models were obtained with multivariate habitat factors; there was no significant model for upland–OG during spring (Table 4). Factor 2 was correlated with habitat use in peatland–MC during both seasons, whereas factor 3 was a correlate of autumn squirrel captures in upland–OG. Factor 2 represented habitat space with more large trees and snags and decayed down wood, but less shrub and seedling cover. A unit increase in factor 2 increased the odds of capturing flying squirrels during spring and autumn by a multiple of 1.6 and 1.5, respectively. Factor 3 captured variation in habitat space associated with more *Vaccinium* cover and less deciduous shrub cover, herb cover, and free water. A unit increase in factor 3 increased the odds of capturing a flying squirrel by a multiple of 2.1.

Model performance: habitat variables vs. multivariate factors

The percentage of sites correctly predicted varied seasonally and between habitats for both types of models (Table 5). For variable-based models, the percentage of microsites classified correctly ranged from 62.1% to 85.0%. Sensitivity (percentage of capture sites correctly classified) and specificity (percentage of noncapture sites correctly classified) ranged between 61.4% and 100%, and 0% and 62.7%, respectively. With the exception of upland–OG model during autumn, which performed best in predicting sites that captured flying squirrels, about one-third of the trap stations were incorrectly classified as capture sites. Neither autumn model misclassified a capture site (i.e., sensitivity = 100%); however, a relatively large number of capture sites were misclassified (false negatives) with spring models (Table 5). The percentage of microsites that were correctly classified with factor-based models was 49.9–69.5%. Sensitivity and specificity

TABLE 4. Stepwise logistic regression models of multivariate habitat factors correlated with flying squirrel microhabitat use in peatland–scrub/mixed-conifer (peatland–MC) and old-growth western hemlock/Sitka spruce rain forest (upland–OG) during spring and autumn 1998–2000, Prince of Wales Island.

Model	Factor†	Chi-square test (*P*)	Parameter estimate (1 SE)	Odds ratio‡ (95% CI)	Model goodness of fit§ (*P*)
Spring					
Peatland–MC	2	0.0023	0.480 (0.16)	1.6 (1.2–2.3)	0.78
Upland–OG	N/A				
Autumn					
Peatland–MC	2	0.0212	0.426 (0.19)	1.5 (1.1–2.3)	0.26
Upland–OG	3	<0.0001	0.726 (0.20)	2.1 (1.4–3.1)	0.98

Note: N/A denotes no significant model.

† Orthogonal, multivariate factors from factor analysis of habitat variables. For peatland–MC, factor 2 is density of large trees and snags; for upland–OG, factor 3 is understory composition and structure (mostly *Vaccinium* cover).

‡ Effect of a one-unit increase in the value of the variable (e.g., percent cover) on the probability of capture (SAS Institute 2000).

§ Results of Hosmer and Lemeshow test (SAS Institute 2000), reported as the probability (*P*) that the model will be improved by an additional habitat variable.

TABLE 5. Performance of logistic regression models of habitat variables (''Variable'' columns) and multivariate factors (''Factor'' columns) in predicting flying squirrel microhabitat use in peatland–scrub/mixed-conifer (peatland–MC) and old-growth western hemlock/Sitka spruce rain forest (upland–OG) spring and autumn 1998–2000, Prince of Wales Island.

Model	Probability level (%)	Correct (%)		Sensitivity (%)		Specificity (%)		False positive (%)		False negative (%)	
		Variable	Factor	Variable	Factor	Variable	Factor	Variable	Factor	Variable	Factor
Spring											
Peatland–MC	51	62.1	54.9	61.4	40.4	62.7	70.0	36.8	41.7	39.0	47.0
Upland–OG†	64	65.6		99.4		5.6		34.8		16.8	
Autumn											
Peatland–MC	70	70.0	49.9	100	41.0	0	70.6	30.0	23.5	‡	66.1
Upland–OG	85	85.0	69.5	100	72.2	0	54.1	15.0	10.1	‡	74.5

Notes: ''Probability level'' is the expected probability of a capture, which is based on the observed or prior probability. (For consistency within this paper, these values are reported as percentages instead of proportions.) ''Correct'' is the fraction of trap stations that were correctly classified. ''Sensitivity'' is the fraction of capture sites that were correctly classified. ''Specificity'' is the fraction of noncapture sites that were correctly classified. ''False positive'' is the fraction of trap stations predicted to capture an animal that were incorrectly classified as a capture site. ''False negative'' is the fraction of trap stations predicted to not be a capture site that were incorrectly classified as a noncapture site.

† There was no significant ($P > 0.05$) model of multivariate factors for upland–OG during spring.

‡ Rate was not computable.

were 40.4–72.2% and 54.1–70.6%, respectively. The autumn upland–OG model performed best in predicting the percentage of sites that captured a squirrel and the percentage of capture sites classified correctly.

DISCUSSION

Models of microhabitat use

The overall performance of single habitat variables in predicting microhabitat use was better than habitat models constructed with multivariate factors. The percentage of trap stations correctly classified was consistently higher with variable-based models than models developed from multivariate factors, which, except for upland–old-growth (upland–OG) during autumn, did not depart appreciably from 50%. These results differ markedly from patterns of habitat use reported for flying squirrel populations in the Pacific Northwest (Carey et al. 1999), which can vary considerably across geographic areas (Smith et al. 2003).

Carey et al. (1999) quantified habitat use at two scales: microhabitat use within, and density among, 19 natural and managed forest stands that represented three seral stages and spanned the range of variation in closed canopy forests in the Coast Range of southwestern Oregon. From their analyses within individual stands, they observed that only multivariate habitat factors consistently explained variation in flying squirrel captures among microhabitats. Four multivariate factors correctly classified 60% of points (i.e., trap stations) according to flying squirrel use. Additionally, multivariate factors such as decadence, habitat breadth, and moisture–temperature gradient values (MGV) explained substantially more variation in squirrel carrying capacity (i.e., maximum density) across stands than individual variables (Carey et al. 1999). That they also observed a significant relationship between flying squirrel density and habitat factors among stands demonstrated that multivariate factors explained habitat use at multiple spatial scales (microhabitat and stand level) across a relatively broad range of forest conditions. Drawing also on the findings of studies conducted elsewhere in Oregon and in Washington (Carey 1989, 1991, 1995), they concluded that flying squirrel habitat in the Pacific Northwest is an emergent property of old-growth forest.

We tested their hypothesis by examining whether there was evidence from modeling flying squirrel captures among microhabitats that the habitat of flying squirrels in southeastern Alaska was multifactorial. That our study differed from Carey et al. (1999) in number and types of habitats investigated does not limit the value of comparing correlates of microhabitat use within old-growth stands between regions. Indeed, the causal mechanisms underlying variation in the abundance of flying squirrels among forest habitats likely is linked to resource availability at the scale of individual home ranges (Morris 1984, 1987). Number of quality macrohabitats (i.e., home ranges) determines the carrying capacity of larger habitat patches (forest stands). Still, the fact that we did not include managed stands in our analysis likely diminished our ability to identify specific limiting habitat features of younger, less complex forests, particularly those that emerge as significant correlates of density among managed and unmanaged habitats. But, this should not have hindered our ability to identify emergent factors of old growth forests, particularly with the inclusion and replication of peatland–mixed-conifer (MC) habitats, as we used similar procedures to ask similar questions in similar habitats. Upland–OG and peatland–MC are near opposite ends of a wide range of variation in canopy cover, plant species composition, and vertical and horizontal structure (Harris and Farr 1974, Neiland 1971).

Within peatland–MC alone, there is substantial variation in the density and distribution of forest canopy, in the size (height and diameter) and density of live trees and snags, and in the amount and distribution of downed woody material (Smith et al. 2004). We believe that habitats in our study overlapped much of the range of forest conditions in southwestern Oregon, including managed stands. More importantly, the differences in habitat use we report between studies were apparent within individual stands across a range of forest conditions. That we did not observe ecologically significant variation in habitat use correlated with multivariate factors suggest that the habitat of *Glaucomys sabrinus* in southeastern Alaska is not an emergent property of old growth.

An alternative explanation for the differences we report is that northern flying squirrels in southeastern Alaska may differ ecologically in important ways from populations across the Pacific Northwest. One marked difference in habitat relations between regions was the significance of decadence (especially coarse woody debris), which was the single most important factor explaining flying squirrel habitat use and density in the Pacific Northwest (Carey et al. 1999). The association of flying squirrel populations in Oregon with decadence largely may be a function of their dependence on truffles, i.e., hypogeous ectomycorrhizal fungi (Carey et al. 1999). Many truffle species are directly correlated with old forest attributes, such as coarse woody debris and decayed, downed wood (Amaranthus et al. 1994, Smith et al. 2000, 2002). Furthermore, the most consistent predictor of flying squirrel density across the Pacific Northwest has been frequency or abundance of hypogeous sporocarps (i.e., truffles; Waters and Zabel 1995, Carey et al. 1999, Pyare and Longland 2002).

Equally striking was the significance of habitat breadth and moisture–temperature gradient values (MGV) in southwestern Oregon, which together with decadence, explained 70% of the variation in flying squirrel carrying capacity (Carey et al. 1999). Habitat breadth and MGV apparently reflect ecologically significant gradients and variability within and among stands that influence arboreal rodent communities, including the abundance of northern flying squirrel populations (Carey 1991, 1995, 1996, Carey et al. 1999). In turn, the composition and diversity of arboreal rodent communities likely has shaped the habitat relations of flying squirrel populations in western coniferous forests (Carey 1989, 1991, 1996, Carey et al. 1999, Smith et al. 2003). Within arboreal rodent communities of the Pacific Northwest, interactions among resources and among species sharing resources may have created an ecological environment where populations frequently are not limited by a single factor and their life histories are linked to multiple resources (Carey 1989, 1991, 1996, Carey et al. 1999). That flying squirrel microhabitat use and relative abundance among habitats in the Pacific Northwest are linked to a suite of old forest features may have as much to do with the composition of small mammal communities as the specific life history traits of local populations (Carey et al. 1999).

In temperate rain forests of southeast Alaska, the community structure of arboreal rodents, and the diet of northern flying squirrels (although not mutually exclusive), may be sufficiently different to facilitate a more general lifestyle. In southeast Alaska, northern flying squirrels rely less on truffles, and their diet includes a greater diversity of food items than populations in California, Oregon, or Idaho (Maser et al. 1986, Rosentreter et al. 1997, Carey et al. 1999, Waters et al. 2000, Pyare et al. 2002). The less specialized diet may reflect greater opportunities to use a broader range of rain forest habitats because of less interspecific competition (Carey 1991, 1996, 2000*a*, 2001, Carey et al. 1999). Several investigators have noted the significance of diet in influencing the habitat relations of flying squirrels (Waters and Zabel 1995, Rosentreter et al. 1997, Carey et al. 1999, Pyare and Longland 2002), or their role in forest communities (Maser et al. 1978, 1986, Maser and Maser 1988, Waters et al. 2000). Diet and competitive release were proposed as factors contributing to differences in population density between the Pacific Northwest and southeastern Alaska (Smith and Nichols 2003).

Flying squirrels as a management indicator species (MIS)

The assumption that the northern flying squirrel is a good MIS of north temperate rain forest was not supported by our study. *Glaucomys sabrinus* was proposed as an MIS of the Tongass National Forest (USDA Forest Service 1997), the largest contiguous temperate rain forest in the northern hemisphere, because its populations were thought to indicate conditions of late-seral coniferous forests. This assumption was based on the notion that the ecology of *G. sabrinus* in southeastern Alaska is similar to populations in the Pacific Northwest (Suring 1993), which ostensibly have a complex life history that is linked to a suite of old forest characteristics (Carey et al. 1999, Carey 2000*a*). North temperate rain forests have many attributes that parallel mesic coniferous forests in the Pacific Northwest and the expectation is that habitat relations of flying squirrel populations in southeastern Alaska are similar to populations in the Pacific Northwest (Suring 1993).

We found little empirical support for the hypothesis that the habitat of *Glaucomys sabrinus* in southeastern Alaska is an emergent property of old-growth forest. Rather, variation in microhabitat use largely was explained by a few individual habitat variables and multivariate habitat factors contributed essentially no unique ecological information. This conclusion is supported further by the findings of Smith et al. (2004) that variation in flying squirrel density among forest stands (spring and autumn) was attributable to indi-

vidual habitat variables, some of which (e.g., large trees) were key correlates of microhabitat use in our study. Furthermore, we believe there are ecological differences between regions, particularly in diet and interspecific relations (Pyare et al. 2002, Smith and Nichols 2003, Smith et al. 2004) that are sufficient to explain why the habitat of flying squirrels in temperate rain forest is not multifactorial.

What remain unclear are implications of apparent ecological differences to questions about the suitability of northern flying squirrels as an MIS in temperate rain forest. If the habitat of *G. sabrinus* in southeastern Alaska is not multifactorial, does that limit its utility as an MIS? Or, might there be other aspects of its life history or ecology that renders it an effective MIS? Evidence from our study demonstrated that large standing live and dead trees were ecologically significant correlates of flying squirrel habitat use and density. Large trees and snags also may be crucial or limiting resources for a multitude of species in temperate rain forest, particularly cavity nesters (Hughes 1985, Zarnowitz and Manuwal 1985, Joy 2000) or species whose food resources are more abundant with larger trees (e.g., tree squirrels; Smith et al. 2003). But if this were true, large trees and snags likely would be more useful indicators of rain forest communities because they are easier to measure than flying squirrels. Still, land managers may choose to monitor flying squirrels in southeastern Alaska because their populations are correlated with large trees and snags and because of concerns over the viability of endemic populations (Smith and Nichols 2003). Threatened, endangered, or sensitive status increases the impetus and value of monitoring MIS populations (Simberloff 1998).

There are ecological attributes other than multifactorial habitat that render species suitable as indicators of biological diversity or ecosystem health (Landres et al. 1988, Simberloff 1998, Carey 2000*a*). Flying squirrels may have a keystone role in rain forests of southeastern Alaska. In the Pacific Northwest, flying squirrels are important prey for old-growth-associated predators (Carey et al. 1992, 1999), including small carnivores (e.g., American marten, *Martes americana*) and raptors, and are the primary prey of the northern spotted owl (*Strix occidentalis occidentalis*). In turn, flying squirrels eat sporocarps and disseminate spores of ectomycorrhizal fungi (Maser et al. 1978, 1985, 1986, Forsman et al. 1984, Maser and Maser 1988, Carey 1995, Carey et al. 1999), which are essential symbionts of dominant conifers (e.g., Douglas-fir, *Pseudotsuga menziesii*). However, *G. sabrinus* in southeastern Alaska depends much less on truffles than populations in the Pacific Northwest (Pyare et al. 2002) and there are no known predators that rely on flying squirrels as prey (e.g., Flynn and Schumacher 2001, Lewis 2001). Still, the low diversity of small mammals in southeastern Alaska (MacDonald and Cook 1996) may increase the importance of flying squirrels as prey for raptors or small carnivores, or as disseminators of fungal spores or other reproductive propagules (Bruner et al. 2001).

Alternatively, flying squirrels may be good indicators of processes that are important for conservation planning. A fundamental assumption of the wildlife conservation strategy for the Tongass National Forest is that populations of old-growth reserves will be able to freely interact through dispersal. Thus, widely distributed breeding populations of flying squirrels across the planning area may be a good indicator of landscape permeability (sensu Singleton et al. 2002) in intensively managed landscapes, where successful dispersal of arboreal rodents with limited vagility likely serve as a good benchmark of functional connectivity (Selonen and Hanski 2003).

Perhaps the more important question is whether the expectation of using single species to reflect the health or integrity of an ecosystem is realistic (Simberloff 1998). Although the concept of an indicator species has been around for nearly a century and in common use by researchers and land managers for at least three decades, rigorous analyses of this concept have produced few positive examples of its utility (Lawler et al. 2003). More often than not, investigations have failed to support the underlying assumption of a correlation between the indicator species and the organisms, habitat or, processes it represents (Mannan et al. 1984, Szaro 1986, Niemi et al. 1997, Rolstad et al. 2002). A fundamental issue is that frequently there is little agreement over what the indicator is supposed to indicate (Simberloff 1998), or that the goals and objectives are poorly defined (Landres et al. 1988). Even then, selecting the best indicator species often is not intuitive or well founded in science or knowledge of natural history. More importantly, there is the recognition that managing for one species almost always conflicts with management of other species (Landres et al. 1988, Simberloff 1998).

Several alternatives to MIS have been proposed (e.g., flagship, umbrella, or keystone species), all of which have unique nuances. Of these, keystone species seems to have the most promise (Simberloff 1998). However, identifying keystone species and associated mechanisms that have wide-ranging impacts on communities and ecosystems is no small task. Furthermore, even when good species are identified, using keystone species in conservation planning (like MIS) is not exempt from the shortcomings of relying on a single species to represent the response of entire biological communities to perturbation (Simberloff 1998).

Alternatively, some investigators have proposed more comprehensive approaches including the use of multiple species to monitor communities at the ecoregional scale (Manley et al. 2004), or combining the monitoring of habitat and multiple species across broad scales (Niemi et al. 1997). Regardless, a critical feature of an effective monitoring program is ensuring that the measures of future desirable condition correlate with

the ecological indicators that have been selected. For MIS, this means knowing the biology of the species (Landres et al. 1988, Simberloff 1998) and requires quantitative documentation of habitat associations (Jorgensen 2002, Morris 2003). Simply assuming that a species will be a suitable indicator of desired ecological conditions because it reputedly functions in that role in a similar ecosystem elsewhere can be misleading, counterproductive, and costly.

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MAP ON PAGE 216

TONGASS 77 WATERSHEDS

Melanie Smith

The Tongass 77 (T77), also known as the "Salmon Forest" Proposal, designates key watersheds in Southeast Alaska for permanent protection to safeguard the most important salmonid habitat across the region that is currently open to development status. The proposal is based on a scientific assessment of Southeast Alaska's Coastal Forests and Mountains Ecoregion (Schoen and Dovichin 2007). The assessment resulted in a habitat ranking system for six salmonid species as well as other values. Top watersheds were identified in each of the 14 biogeographic provinces in Southeast Alaska that are not in legislatively protected status, based on combined values for the six anadromous fish species, plus related habitat quality indicators such as old-growth forest, bear and deer habitat, and estuaries.

Salmon were selected as a focal species for forest management because spawning and rearing salmon are widely distributed in streams and rivers throughout Southeast Alaska and because these fish play a fundamental role in the ecology of coastal, freshwater, and terrestrial systems. Salmon are keystone species because they transfer marine-derived nutrients into the terrestrial and freshwater ecosystems, and many terrestrial and freshwater species and ecological processes are inextricably connected to salmon (Willson and Halupka 1995).

The project assessed top watersheds for each biogeographic province in order to account for the unique island biogeography of different areas of the Tongass. The Tongass 77 are therefore a dispersed network of sites identified at the whole watershed scale, employing both a "single large" and "several small" reserve design at the province or ecoregion scale, respectively. This land management strategy is analogous to preserving an ecological investment portfolio (Schindler et al. 2010). The proposal will permanently protect top watersheds in Southeast Alaska.

The Tongass 77 proposal includes all of the top-ranking (i.e. #1) watersheds within all 14 of the biogeographic provinces in Southeast Alaska not under permanent protection, based on values for all six fish species and related habitat conservation targets. Also included in the Tongass 77 are the #1 ranking watersheds for the six individual fish species assessed, as well as the highest ranking watersheds for all salmonids combined. Salmonid species included:

- King (Chinook) salmon (*Oncorhynchus tshawytscha*)
- Red (sockeye) salmon (*O. nerka*)
- Silver (coho) salmon (*O. kisutch*)
- Pink (humpy) salmon (*O. gorbuscha*)
- Chum (dog) salmon (*O. keta*)
- Steelhead trout (*O. mykiss*)

In addition to including valuable fish habitat, the proposal is supplemented with watersheds that capture other biological values in order to ensure the region will sustain a viable ecosystem. The Tongass 77 captures the #1 ranking watershed in each province for the following ecosystem components, which are highly correlated with healthy salmon habitat:

- Estuaries (highly important anadromous fish habitat)
- Riparian large-tree old growth (nutrient exchange, large woody debris, cold water refuge, erosion stability)
- Black and brown bear (*Ursus americanus* and *U. arctos*) summer habitat (correlated with salmon concentration areas)
- Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) wintering habitat (indicative of healthy upland forest at the watershed scale)
- Marbled Murrelet (*Brachyramphus marmoratus*) nesting habitat (an ecological link between old-growth forest and the marine ecosystem).

John Schoen

Waterfall Bay (Dall Island) is one of the Tongass 77 watersheds.

MAP ON PAGE 216

The proposal included all identified top-ranked watersheds in Southeast Alaska, except those: already protected, in non-federal ownership, actively managed for other values (such as urban recreation, experimental forest, or active timber sale), or lacking public support (for example, the strong landowner opposition to protecting the Taku, which is the top salmon watershed in all of Southeast Alaska). In addition to the #1 watersheds, the proposal included several carefully chosen individual watersheds deemed important through additional review by scientists and fishermen. Additional watersheds met one or more of the following criteria:

- Based on all salmonid values combined, fell within the top 10% of watersheds in Southeast Alaska (without the biogeographic province filter)
- Based on all (salmonid and other) habitat correlates combined, fell within the top 10% of watersheds in Southeast Alaska (without the biogeographic province filter)
- Fell within the top five watersheds for a biogeographic province
- Identified as a Tier 1 watershed based on ecological optimization modeling as described by Albert and Schoen (2007). Tier 1 watersheds fall within the top 25% of each biogeographic province, using an evaluation of the smallest footprint to achieve the highest value for the combination of all salmonid and other habitat correlates combined
- ADFG data indicated exceptional salmon production and/or diversity.

The Tongass 77 proposal was based on several years of rigorous data collection, scientific analysis, and modeling, combined with local knowledge of the highest productivity areas. The proposal therefore captures the most important places in Southeast Alaska's Tongass National Forest for ensuring the long-term existence and health of the Southeast Alaska ecosystem and salmon fishery.

CONSERVATION ISSUES

The Tongass 77 Watersheds make up the most ecologically important but unprotected 1.89 million ac (764,855 ha) of the 17 million ac (6,879,656 ha) Tongass National Forest. Conservation of whole watersheds maintains ecological processes and local habitat diversity (Lertzman and MacKinnon 2013). Including key watersheds across provinces ensures well-distributed, high-quality habitat that will sustain population viability and ecosystem integrity across Southeast Alaska. The Tongass 77 includes both intact and developed watersheds, in order to capture those watersheds most important to ensuring long-term viability of the region as a salmon forest.

Four of the T77 watersheds have changed status since the proposal was developed. In 2015, the National Defense Reauthorization Act included a provision for the transfer of lands to Sealaska Corporation. To the dismay of conservation groups, that land transfer included Nutkwa Inlet, one of the T77 watersheds proposed for LUD II designation. At the same time, however, three other watersheds were placed into LUD II status as part of the Sealaska deal. Those were Lovelace Creek, Lake Kushneahin, and Sarkar Lakes.

Currently Southeast Alaska has a $1 billion fishing industry that supports 7,000 jobs, and a $1 billion tourism and recreation industry which supports another 10,000 jobs. The same watersheds that support ecological values also contribute to Southeast Alaska's economic vitality. Trout Unlimited and Audubon Alaska recommend permanent protection for the remaining Tongass 77 watersheds to continue these opportunities for future generations.

MAPPING METHODS

The Tongass 77 watersheds are based on the collection of spatial data generated by Audubon Alaska and TNC for the Conservation Assessment and Resource Synthesis for the Coastal Forests and Mountains Ecoregion (Schoen and Dovichin 2007), as well as scientific research and local knowledge from fishermen collected by Trout Unlimited.

More specific information about mapping methods for each focal resource appears in the summaries for Estuaries, Productive Old Growth, Anadromous Fish Species Richness, King Salmon, Red Salmon, Silver Salmon, Pink Salmon, Chum Salmon, Marbled Murrelet, Sitka Black-tailed Deer, Black and Brown Bears, and Conservation Area Design.

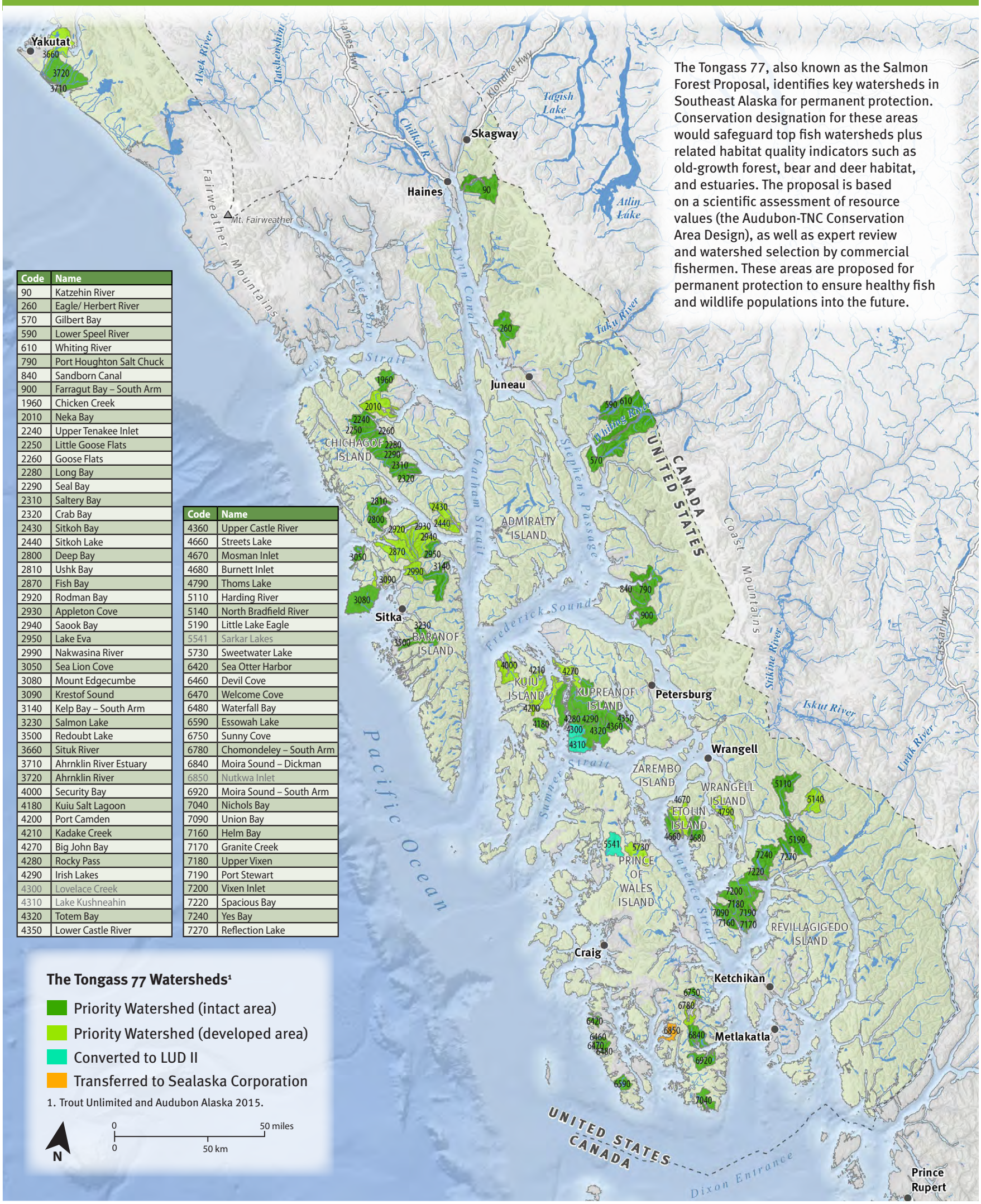
MAP DATA SOURCES

- Tongass 77 watersheds: Trout Unlimited and Audubon Alaska (2015).

John Schoen

Tongass 77 Watersheds

The Tongass 77, also known as the Salmon Forest Proposal, identifies key watersheds in Southeast Alaska for permanent protection. Conservation designation for these areas would safeguard top fish watersheds plus related habitat quality indicators such as old-growth forest, bear and deer habitat, and estuaries. The proposal is based on a scientific assessment of resource values (the Audubon-TNC Conservation Area Design), as well as expert review and watershed selection by commercial fishermen. These areas are proposed for permanent protection to ensure healthy fish and wildlife populations into the future.



Code	Name
90	Katzehin River
260	Eagle/ Herbert River
570	Gilbert Bay
590	Lower Speel River
610	Whiting River
790	Port Houghton Salt Chuck
840	Sandborn Canal
900	Farragut Bay – South Arm
1960	Chicken Creek
2010	Neka Bay
2240	Upper Tenakee Inlet
2250	Little Goose Flats
2260	Goose Flats
2280	Long Bay
2290	Seal Bay
2310	Saltery Bay
2320	Crab Bay
2430	Sitkoh Bay
2440	Sitkoh Lake
2800	Deep Bay
2810	Ushk Bay
2870	Fish Bay
2920	Rodman Bay
2930	Appleton Cove
2940	Saook Bay
2950	Lake Eva
2990	Nakwasina River
3050	Sea Lion Cove
3080	Mount Edgecumbe
3090	Krestof Sound
3140	Kelp Bay – South Arm
3230	Salmon Lake
3500	Redoubt Lake
3660	Situk River
3710	Ahrnklin River Estuary
3720	Ahrnklin River
4000	Security Bay
4180	Kuiu Salt Lagoon
4200	Port Camden
4210	Kadake Creek
4270	Big John Bay
4280	Rocky Pass
4290	Irish Lakes
4300	Lovelace Creek
4310	Lake Kushneahin
4320	Totem Bay
4350	Lower Castle River

Code	Name
4360	Upper Castle River
4660	Streets Lake
4670	Mosman Inlet
4680	Burnett Inlet
4790	Thoms Lake
5110	Harding River
5140	North Bradfield River
5190	Little Lake Eagle
5541	Sarkar Lakes
5730	Sweetwater Lake
6420	Sea Otter Harbor
6460	Devil Cove
6470	Welcome Cove
6480	Waterfall Bay
6590	Essowah Lake
6750	Sunny Cove
6780	Chomondeley – South Arm
6840	Moira Sound – Dickman
6850	Nutkwa Inlet
6920	Moira Sound – South Arm
7040	Nichols Bay
7090	Union Bay
7160	Helm Bay
7170	Granite Creek
7180	Upper Vixen
7190	Port Stewart
7200	Vixen Inlet
7220	Spacious Bay
7240	Yes Bay
7270	Reflection Lake

Map 7.10: Tongass 77 Watersheds

Alaska Regional Climate Projections

Who We Are

- **SNAP** - The **Scenarios Network for Alaska Planning** is a network linking university researchers with communities and resource managers. Through collaborative partnerships involving data sharing, research, modeling, and interpretation of model results, SNAP addresses some of the complex challenges of adapting to future conditions.
- **CES** - The **Cooperative Extension Service** was established by the US Congress as the educational outreach component of the national land grant university system—in Alaska, the University of Alaska Fairbanks. They conduct research and provide educational outreach statewide.
- **ACCAP** - The mission of the **Alaska Center for Climate and Policy** is to assess the socio-economic and biophysical impacts of climate variability in Alaska, make this information available to local and regional decision-makers, and improve the ability of Alaskans to adapt to a changing climate.

Planning for Change

Background

Alaskans are faced with many new challenges, including high energy costs and the impacts of climate change. Rising energy costs have impacted the costs of food and other services as well as fuel prices. Changes in temperature and moisture can trigger profound landscape-level changes such as sea level rise; changing patterns of storms, flooding, or fire; and different migration routes, breeding patterns, or survivorship of fish and wildlife.

Everyone—from engineers to wildlife managers to farmers—will need to take economic change, social change, and climate change into account when planning for the future, in order to avoid costly mistakes. Planning requires objective analysis—including clear explanations of the uncertainty inherent in all forms of forecasting. ***Together, SNAP, ACCAP, and CES can provide a variety of services that may help you in meeting your community planning needs.***

SNAP climate projections

As a starting point, SNAP offers statewide maps of temperature and precipitation projections, and basic data for 353 communities. These projections are based on global models used by the Intergovernmental Panel on Climate Change (IPCC), using a moderate scenario (A1B). Results from the five models that perform most accurately in Alaska and other northern regions were downscaled using local data.

Climate Change by Region

Introduction

The following graphs are provided as examples of climate change projections for communities around the state. Each graph shows mean monthly temperatures **(°F)** or mean monthly precipitation **(inches)** for three periods: 1961–1990 (actual historical data), 2041–2050, and 2091–2100 (projections). Note that graph scales differ by region.

Statewide trends

In general, temperatures and precipitation are expected to increase across all regions. Temperature increases are predicted for every month, and increases are expected to continue throughout the century. The growing season is likely to increase statewide. Note that precipitation alone does not predict ecosystem moisture limitations. Increased plant growth and increased evaporation due to

The University of Alaska is an AA/EEO employer and educational institution.

higher temperatures may more than offset the additional precipitation, resulting in overall drying of soils.

Uncertainty

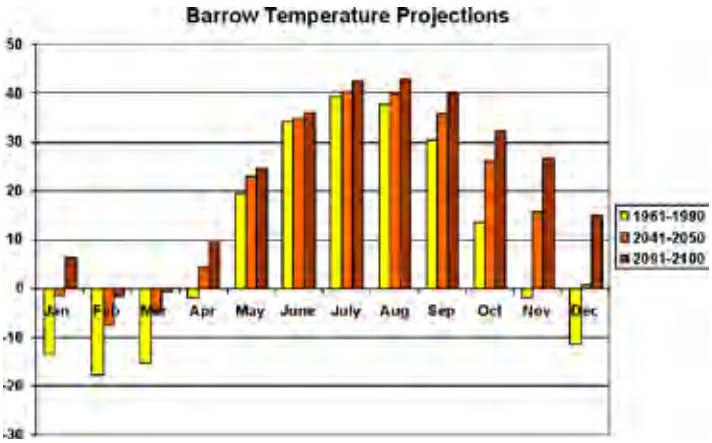
While values are based on the best available models, they are estimates only. There is variation among the five models used, and annual variation within each model. In general, uncertainty is higher for precipitation than for temperature, particularly for dry regions where small differences can represent large percentage changes. Interpretation of the impacts of temperature and precipitation change adds additional uncertainty.

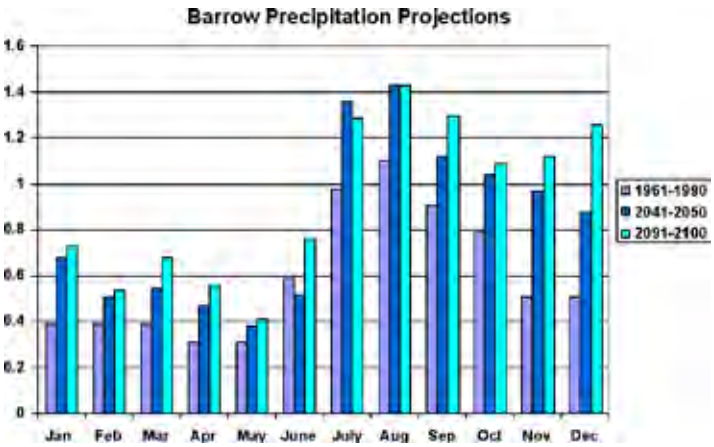
North Slope and Northwest coast

For some coastal communities, **erosion** is by far the most pressing issue. Loss of sea-ice and thawing of frozen ground along coastlines allows for greater wind and water erosion, especially during severe storms. Warming oceans and melting glaciers increase ocean volume, causing sea level rise.

Loss of sea-ice and other climate shifts are also changing habitat for arctic species, impacting **subsistence** activities.

Significant temperature change is predicted, particularly in fall and winter months. Note that in Barrow, June temperatures are projected to rise only 2–3° this century, but October-March temperatures are projected to increase by 20–25°

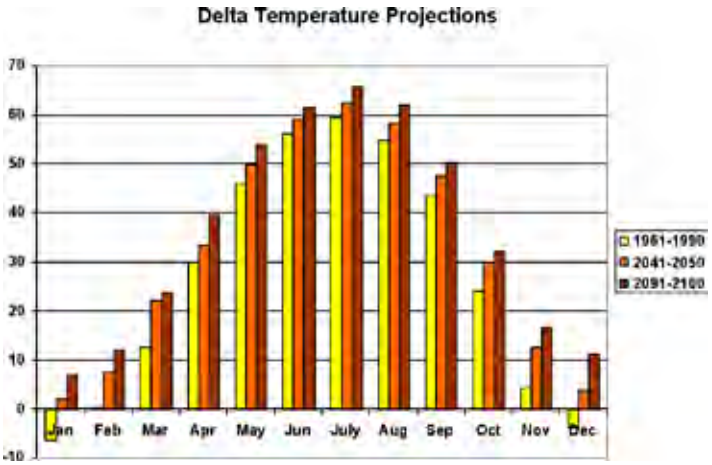


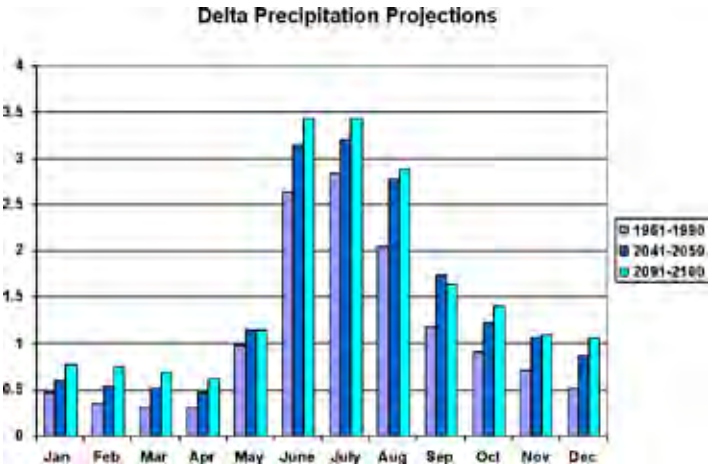


Warmer temperatures and a longer growing season are already causing an increase in shrub cover in the tundra, and higher evapotranspiration is likely to cause drying of some soils and wetlands. Thunderstorms may also become more frequent. Shrub cover, drying, and lightning together may result in higher fire incidence.

Warmer winter temperatures and lower water availability may impact the manner in which heavy industry can operate on the North Slope.

Interior





In central Alaska, **changes in fire patterns** are likely to have significant impacts on ecosystems. Fires may become more frequent and more intense due to drying soils. Note that little or no increase in precipitation is expected in spring (May), and that shorter winters may mean less snowpack even with higher overall precipitation.

Winter temperatures are projected to increase by as much as 15° by 2100. Insect outbreaks may spread north into the boreal forest as winter conditions become warmer, since cold winters are often the population-limiting factor for insects such as the spruce bark beetle.

Permafrost is currently discontinuous in the Interior. With increased temperatures, **permafrost thaw** may affect roads, pipelines, buildings, and other infrastructure.

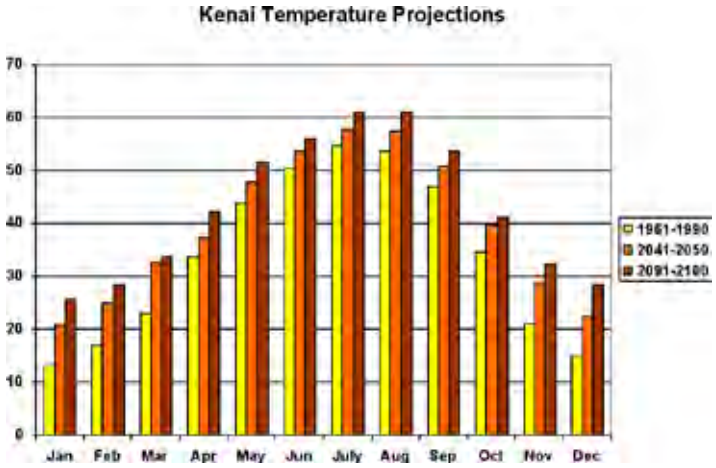
A significantly longer growing season may have a positive impact on agriculture in the Interior, allowing for longer-season crops and reduced need for greenhouses. However, this more favorable growing environment may also allow for more invasive plants to enter the region. The migration of spruce northward and upward in elevation and lodgepole pine into the Interior is likely.

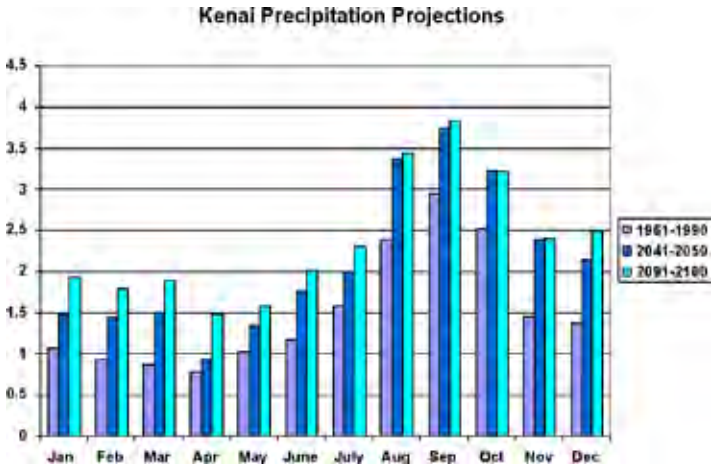
South Central

In south central Alaska, warming temperatures and associated drought stress may increase invasive species and other **species shifts**, including the incidence of insect outbreaks. Warmer weather, drying, and insect-killed trees may also increase the incidence and severity of **forest fire**.

Note that mean temperatures in Kenai are projected to rise from well below freezing in November and March to slightly above freezing, with corresponding increases in December-February. Shorter milder winters may allow for greater survival of pest species that have been naturally excluded previously, as was the case with recent bark beetle outbreaks in this region.

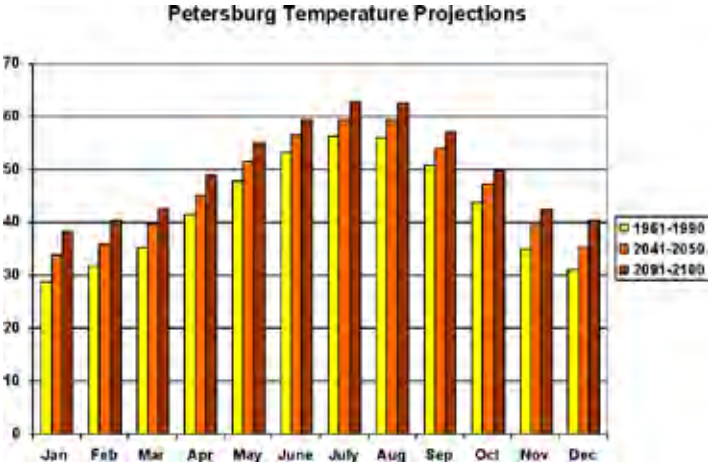
Species shifts may negatively impact ecosystem function and subsistence activities. However, longer growing seasons and milder winters may expand the agricultural potential of this region, allowing greater success for long-season annual crops as well as for fruit trees and other perennials.

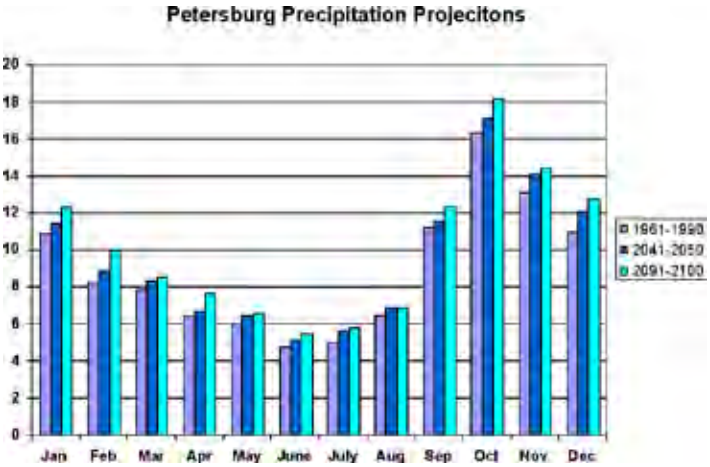




In coastal areas, storm severity may increase, with associated risks from flooding and erosion.

Southeast





Changing ocean temperature, invasive species, erosion and storms may impact the **fishing industry** in southeast Alaska. However, since fisheries in other parts of the world may be impacted also, it is hard to predict the relative competitiveness of Alaska fisheries.

Tourism is a major source of revenue in southeast Alaska, and longer and warmer summers may benefit this industry. However, our models predict relatively modest increases in temperatures during the May-September season, and larger changes from October to April.

Although high precipitation has generally prevented forest fire from being a major driver in southeast Alaska in the past, warming and drying of soils may increase **fire risk** over the coming decades.

Our models suggest that below-freezing temperatures and snowfall will become increasingly rare in this region, at least at low elevations. Note that mean winter temperatures in Petersburg are projected to rise from below freezing to well above freezing in the next few decades.

Southwest/Aleutians

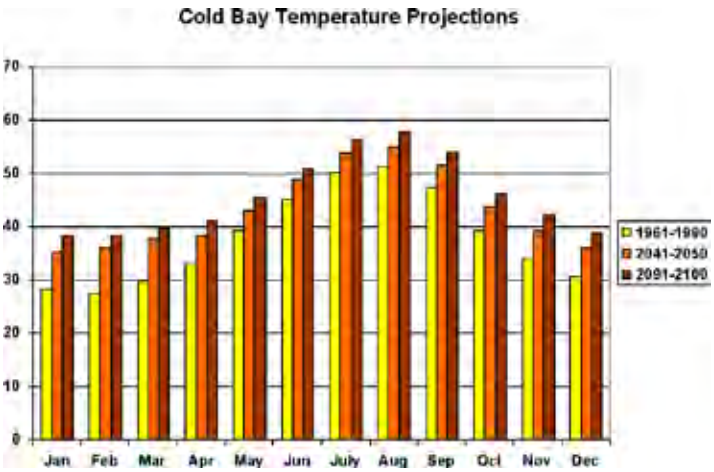
Increased incidence and severity of **storms** are likely to be of concern in Southwest Alaska.

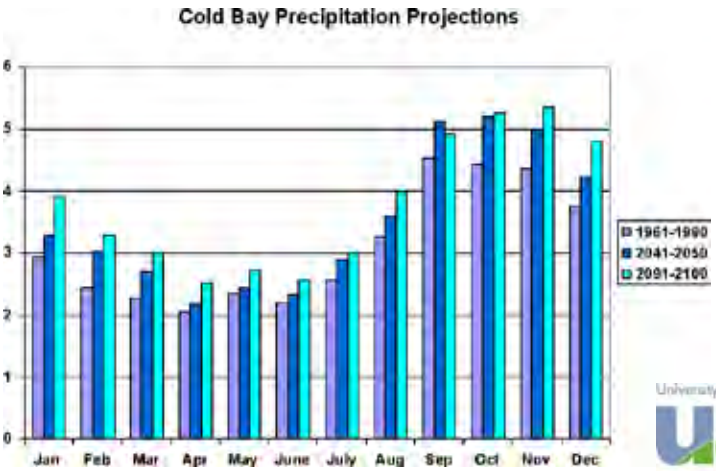
As a result of sea level rise and storm surges, **erosion** may also be a problem. However, because these coastal areas are historically free of sea ice they will probably not experience the more extreme erosion of more northern regions.

In many parts of the Aleutians, decreased (or completely absent) snowfall may occur as mean winter temperature rise above freezing. Lack of hard frost may also drive species shifts and allow invasive species to encroach, although more remote islands may be less susceptible than other parts of the state due to the effects of island biogeography. In fact, it's possible that in some cases species shifts may not occur as rapidly as needed to keep up with changing climate conditions.

Tree line will continue to move westward as wet tundra areas dry and become occupied by the westward movement of the boreal forest.

Warming ocean temperatures are **altering the Bering Sea ecosystem**, impacting fish, marine mammals, and birds.





Additional Information

Sample questions

The group(s) most suited to assist with each question are noted in italics.

- How can we make a difference in our future given the realities that we face? ***SNAP, CES, ACCAP***
- What are the simplest and most cost effective community changes that will improve quality of life, given current and future energy needs and climate conditions? ***SNAP, CES, ACCAP***
- What are the specific climate projections for our community? ***SNAP***
- How might we develop a sustainable community woodlot program to reduce fossil fuel use? Can we get carbon credits for such a program? ***CES***
- Are there economically viable products that we can produce and sell to a larger market? ***CES***
- How might climate change impact natural resources, businesses, and infrastructure in our community? ***SNAP***
- Are there energy programs available? ***CES***
- Can we develop an educational program to raise climate change awareness and engage students in monitoring impacts? ***CES, SNAP, ACCAP***
- Can our community monitor the efficacy of emission reduction efforts? ***CES***
- Can we do more to grow our own food and become more self-sufficient? ***CES***

Contact Us

- To learn more about Alaska climate projections and how your agency or community can become a SNAP collaborator, visit the SNAP website: **www.snap.uaf.edu** or contact: Dr. Nancy Fresco: ffnlf@uaf.edu (907) 474-2405
- For additional information about climate change in Alaska, visit the ACCAP website: **www.uaf.edu/accap** or contact Dr. Sarah Trainor: accap@uaf.edu phone: (907) 474-7878
- For more information about Cooperative Extension services through the University of Alaska Fairbanks: **www.alaska.edu/uaf/ces**
- *Valuable additional information can be found at the **Alaska Climate Change Strategy web site: www.climatechange.alaska.gov***

University of Alaska Geography Program
uagp

SNRAS Pub. No. MP 2009-04
School of Natural Resources & Agricultural Sciences
PO Box 752700, Fairbanks AK 99775-7200
www.uaf.edu/snras/ • fynras@uaf.edu

Congress of the United States
Washington, DC 20510

November 18, 2019

Phillis K. Fong
Inspector General
U.S. Department of Agriculture
Room 117-W Jamie Whitten Building
1400 Independence Avenue SW
Washington, DC 20250

Dear Ms. Fong:

We write to request an investigation regarding the potential misuse of a recent U.S. Forest Service (USFS) grant to the State of Alaska. We are concerned by a recent news report indicating the State of Alaska used a federal fire assistance grant for non-fire purposes, including a subgrant to a timber industry stakeholder to support a rulemaking regarding roadless area management on the Tongass National Forest.

In January 2018, the State of Alaska requested that USDA consider creating a state-specific rule to exempt the Tongass National Forest from the Roadless Rule, a rule which establishes nationwide prohibitions on harvesting timber and road construction on certain National Forest Service lands in order to protect these lands. Alaska sought a full exemption from the rule.

According to a September 24, 2019 press report on Alaska Public Media,[1] the State of Alaska's Fire Staff Officer requested $2 million in grant funding, apparently under a State fire assistance grant, which is typically used to help communities prevent and suppress wildfires. The documentation in this press report shows the purpose for seeking the grant funding was to cooperate and coordinate in carrying out the rulemaking to exempt the Tongass National Forest from the Roadless Rule. According to this press report, the State of Alaska awarded some of the funds from this grant to the Alaska Forest Association, an industry trade association advancing the business interests of Alaska's timber industry. The press report also notes that funding was not granted to other stakeholders, including the Organized Village of Kake, a tribal government that has concerns about the impact of large-scale logging on their community.

The Cooperative Forestry Assistance Act of 1978's grant authorities appear to primarily, or even wholly, provide financial assistance to states for the prevention and suppression of fires on non-Federal forest lands. However, Alaska's revised application for these funds contains no mention of fire activities and indicates they will be used to help fulfill their cooperating agency responsibilities for their petition to the USFS to revise the Roadless Rule on federal lands.

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[1] Jenkins, E. 'Faced with an important decision on the Tongass, why is the federal government supporting Alaska's timber industry?' *KTOO Public Media*, 24 September 2019, https://www.ktoo.org/2019/09/24/faced-with-an-important-decision-on-the-tongass-why-is-the-federal-government-supporting-alaskas-timber-industry/. Accessed 5 November 2019.

The Tongass is our largest National Forest and is essential to addressing the climate crisis. It is critical that we ensure this taxpayer funded grant was properly awarded and used. We request an investigation into whether the Forest Service properly granted these funds to the State of Alaska and whether the funds were used appropriately.

In reviewing this matter, we ask that you investigate the following questions:

1. Under what specific grant program was the $2 million grant to the State of Alaska awarded, and was the grant properly awarded, including being awarded for purposes allowed under the grant program?

2. What was this grant funding used for, and was it properly used by the State of Alaska and any subgrantees, including the Alaska Forest Association?

3. Were other Alaska stakeholders such as the Organized Village of Kake made aware of or awarded any funding to support their abilities to assist in the rulemaking?

4. What communication between the USFS, the State of Alaska, the Alaska Forest Association, or any of its members led to the State's request for this grant funding?

5. Is it permissible for the USFS to grant federal funds to a state to enable it to help convince USDA to grant the rule change it had requested?

Sincerely,

Debbie Stabenow
Ranking Member
U.S. Senate Committee on
Agriculture, Nutrition, & Forestry

Raúl M. Grijalva
Chairman
U.S. House Committee on
Natural Resouces

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Natural Resources
COMMISSIONER'S OFFICE
550 W 7th #1400
Anchorage, AK 99501
Main: 907.269.8431
Fax: 907.269.8918

January 19, 2018

U.S. Department of Agriculture
Attention Sonny Perdue, Secretary of Agriculture
1400 Independence Avenue, S.W.
Washington, DC 20250

Dear Secretary Perdue,

Enclosed you will find a request from the State of Alaska to consider a petition for rulemaking on the applicability of the 2001 Roadless Rule to the Tongass National Forest in Alaska. The history of the exemption and the ensuing legal challenges are covered in detail in our petition and exhibits. The State also lays out clear and sound rationale for why an exemption should be addressed through the rulemaking process.

The State appreciates your interest in this topic. We see this as one of many significant opportunities to work with you to support a diverse and robust forest products sector in Southeast Alaska. Rebuilding this sector will create jobs and prosperity for our rural communities located in the Tongass National Forest.

The State looks forward to participating in the process and is available to answer questions you or your staff may have on this subject.

Sincerely,

Andrew Mack

Andrew T. Mack
Commissioner

cc:
Bill Walker, Governor of Alaska
U.S. Senator Lisa Murkowski, Chairman, Senate Energy & Natural Resources Committee
U.S. Senator Daniel S. Sullivan
U.S. Representative Don Young
Tony Tooke, Chief USFS
Cathy Giessel, State Senator and Chair Senate Resources Committee
Geran Tarr, State Representative and Co-chair House Resources Committee
Andy Josephson, State Representative and Co-chair House Resources Committee

Before the Department of Agriculture
Washington, DC 20250

To: George Ervin "Sonny" Perdue, Secretary of Agriculture

From: The State of Alaska, Department of Natural Resources

Re: The Department of Agriculture Roadless Area Conservation Rule and
The 2016 Tongass National Forest Land and Resource Management Plan

Date: January 19, 2018

STATE OF ALASKA
PETITION FOR USDA RULEMAKING TO EXEMPT THE TONGASS NATIONAL FOREST FROM APPLICATION OF THE ROADLESS RULE AND OTHER ACTIONS

I. SUMMARY

In a 2003 Record of Decision (ROD) Ex. 1, the USDA promulgated a regulation (Tongass Exemption) exempting the Tongass National Forest (Tongass) from the Roadless Area Conservation Rule (Roadless Rule). In this ROD, the USDA provided in-depth analysis of the requirements and limitations of the Tongass Timber Reform Act (TTRA) and the Alaska National Interest Lands Conservation Act (ANILCA) if the Roadless Rule were applied to the Tongass. After this statutory analysis, the USDA concluded that the best way to implement the spirit and the letter of these laws was to exempt the Tongass from the Roadless Rule.

The USDA also concluded that exempting the Tongass was consistent not only with the intent of Congress, but also with sound management of the Tongass because roadless areas in the Tongass are adequately protected without adding the additional restrictions in the Roadless Rule. USDA stated that roadless areas are common, not rare in the Tongass and the vast majority of the 9.34 million acres of roadless areas have restrictions on road building and timber harvest irrespective of the Roadless Rule. Even without the Roadless Rule, only about four percent of the Tongass is designated as suitable for timber harvest. *See* ROD, Ex. 1.

In its decision to exempt the Tongass, USDA weighed the value of imposing these unnecessary additional restrictions against the very significant social and economic costs to Southeast Alaska that were discussed in depth in the 2001 Roadless Rule decisional documents. When USDA reconsidered the same facts in this second rulemaking that it had considered in 2001, the USDA this time concluded that the needs of the people of

Alaska outweighed adding more restrictions when roadless areas in the Tongass are adequately protected without the Roadless Rule.

After environmental interest groups challenged the Tongass Exemption in 2009, the USDA aggressively defended the rule in its 2010 opening brief in the Federal District Court for the District of Alaska. *See* USDA Brief Ex. 2. USDA argued that "the Tongass Exemption was a well-reasoned decision, supported by the evidence" and that after reweighing the same economic, social and environmental factors considered in the 2001 ROD, USDA concluded that "the roadless values on the Tongass could be protected and social and economic impacts minimized by exempting the Tongass from the Roadless Rule. USDA Brief at 1-4.

The District Court nevertheless invalidated the Tongass Exemption, but upon appeal, a three-judge panel of the Ninth Circuit Court of Appeals reversed and upheld the Exemption. However, in a 6-5 *en banc* decision, the Ninth Circuit struck down the Tongass Exemption on a procedural ruling, holding that the USDA failed to adequately explain its change of position from the 2001 Roadless Rule to the 2003 Tongass Exemption. *See En Banc* Opinion, Ex.3. The Court did not find any substantive legal infirmities with the Tongass Exemption, that is, the Court did not hold that the USDA analysis or rationale could not support exempting the Tongass, or that the USDA reached the wrong decision, but only that USDA failed to provide an adequate explanation of its change of position from 2001. No judge questioned the fact that the USDA had a right to change position on exempting the Tongass, if the change was adequately explained. *Id.*

The rationale USDA provided for exempting the Tongass in the 2003 ROD and again in the 2010 USDA Brief remains valid today. The extensive damage resulting from the application of the Roadless Rule to the economic and social fabric of Southeast Alaska remains as real today as it was 15 years ago, while the Tongass roadless values remain more than adequately protected without the Roadless Rule. Therefore, for the reasons more fully explained below, the State of Alaska (State) respectfully requests that the Secretary of Agriculture grant this petition and direct the USDA and USFS to immediately undertake a rulemaking to consider once again exempting the Tongass from the Roadless Rule.

In addition, the State requests that the Secretary also direct the USFS to undertake a revision to the 2016 Tongass Land & Resource Management Plan (TLMP). In a recent amendment to the TLMP, the USFS implemented the Roadless Rule by including many of the most restrictive provisions and prohibitions of the Roadless Rule into the fabric of the TLMP. As a result, even if the Tongass is once again exempted from the Roadless Rule, these Roadless provisions would remain in the TLMP and be independently applicable unless also removed from the TLMP. A Forest Plan amendment or revision under the 2012 USFS planning rules is the mechanism for the Executive Branch to

remove these provisions. The State also requests that the provisions inserted into the TLMP in 2016 requiring a rapid transition from old growth to young growth timber harvest also be revised.

II. HISTORY OF THE TONGASS EXEMPTION

Controversy over federal management of the Tongass goes back many decades. The most relevant history regarding whether to exempt the Tongass from the Roadless Rule begins at the turn of the 21st Century in the waning days of the Clinton Administration. Entire books have been written on the high-profile policy and legal battles over the Tongass spanning many decades, and the basic facts have been set forth in many legal briefs and judicial decisions. *See e.g.* USDA Brief Ex.2 at 1-5; State Brief in the Federal District Court for the District of Columbia (State Roadless Rule Brief), Ex. 4 at 1-3; and *State of Alaska v. USDA,* case 11-1122 RLJ, Opinion filed 9/20/17, Ex. 5 at 7-15. Therefore, only a very brief summary is presented here in addition to the more comprehensive discussions in the attached exhibits.

Beginning with an interim rule in 1999, as the USDA developed the Roadless Rule, the administration's preferred approach was to exempt the Tongass or to limit its application. USDA Brief, Ex. 2 at 1-2. It was not until the final decision in the 2001 ROD, at the very conclusion of the rulemaking process, that USDA unexpectedly fully and immediately applied the Roadless Rule to the Tongass. *Id.*

During the rulemaking process, USDA recognized that the Tongass would be so uniquely and severely impacted by the Roadless Rule that what was effectively a separate rulemaking within a rulemaking was conducted for the Tongass. USDA recognized that the Roadless Rule would severely interfere with seeking to meet timber demand as required by Tongass Timber Reform Act, that the social and economic impact on Southeast Alaska would be severe, and that adequate protections were in place to protect the environmental values of the Tongass without the Roadless Rule. *Id.* at 2-5. These were the rationale stated throughout the process for choosing limited, if any, application to the Tongass as the USDA preferred alternative; at least until the surprise ending when in the final ROD the Roadless Rule was made immediately fully applicable to the Tongass. *Id.* For example, the USDA preferred alternative in the draft environmental impact statement was "Tongass exempt". *Id.*

Many lawsuits immediately followed promulgation of the Roadless Rule, including one by the State of Alaska challenging its application to Alaska national forests. In 2003, a temporary rule exempting the Tongass (Tongass Exemption) was promulgated to satisfy a settlement of Roadless Rule litigation between USDA and the State of Alaska. It is this temporary rule that was invalidated by the Federal District Court in Alaska in 2011. The rulemaking to promulgate permanent exemptions for both

national forests in Alaska – also a term of the settlement agreement – was never commenced after the 2005 State Petitions Rule replaced and effectively (at least temporarily) repealed the Roadless Rule nationwide. *Id.*

However, a federal court in California invalidated the State Petitions rule in 2006 and reinstated the Roadless Rule nationwide even though it had been invalidated by a federal court in Wyoming and was enjoined nationwide. The reinstatement of the Roadless Rule was, however, explicitly made subject to the Tongass Exemption rule, and therefore the Tongass remained exempt until the District Court in Alaska invalidated it in 2011. *Id.*

The Tongass Exemption rule then remained in litigation until the United States Supreme Court on March 29, 2016 declined the State's Petition for Certiorari for review of the Ninth Circuit *en banc* decision invalidating the Tongass Exemption rule due to the argued inadequate explanation of USDA's change in policy.

Following the loss of the Tongass Exemption, the State and many supporting intervenors continue to appeal the Roadless Rule and the Roadless Rulemaking decision to apply the rule to the two national forests in Alaska in the United States Court of Appeals for the District of Columbia Circuit. If the Court rules in the favor of the State, three different remedies are possible depending upon which claim(s) the case is decided; the Roadless Rule could be invalidated nationwide, it could be invalidated as applied to Alaska or it could be invalidated solely as applied to the Tongass.

III. CONTINUING RATIONALE FOR EXEMPTING THE TONGASS

A. Good Policy

Rationales for exempting the Tongass from the Roadless Rule in a new USDA rulemaking are not entirely equivalent to Alaska's legal claims and arguments challenging the Roadless Rule in federal court. The most important difference is that USDA can enact or change policy via a rulemaking whether such action is legally mandated or just good policy as determined by the agency. The *en banc* decision of the Ninth Circuit striking down the Tongass Exemption did not in any way cast doubt on USDA's authority to set policy on the Roadless or on the Tongass other than to clarify the extent to which the agency must explain its rationale in the record of decision. *See En Banc* Opinion Ex. 3.

Therefore, the first and most compelling reason that USDA should grant this petition to undertake a rulemaking to restore an exemption for the Tongass is that it remains good policy. The 2010 USDA brief (Ex. 2) supporting the policy decision to exempt the Tongass remains as persuasive today as it was then. No federal court has

opined that there was any issue with the policy choice to exempt the Tongass, but instead ruled only on the procedural flaw of not including a sufficient explanation for the change in policy from the 2001 ROD. The State is therefore requesting that USDA now correct this procedural problem through a new rulemaking and in effect reinstate the Tongass Exemption based on the same sound policy decision it made in 2003. All of the rationales that USDA offered for exempting the Tongass in the 2003 ROD remain valid today. ROD Ex. 1.

B. Compliance with Federal Law

In 2003, USDA offered rationales for exempting the Tongass as policy decisions that the State contends are legal requirements that mandate a Tongass or Alaska exemption. In particular, this includes compliance with ANILCA and the TTRA.

USDA devoted a considerable portion of the 2003 ROD to discussion of these two statutes and ultimately stated that the Tongass Exemption Rule

> "reflects the Department's assessment of how to best implement the letter and spirit of congressional direction along with public values, in light of the abundance of roadless values on the Tongass, the protection of the roadless values already included in the Tongass Forest Plan, and the socioeconomic costs to the local communities of applying the roadless rule's prohibitions." Ex. 1 at 75142.

USDA further stated that ANILCA and the TTRA "provide important congressional determinations, findings, and information relating to management of National Forest System lands on the Tongass." *Id.*

More specifically, USDA explained that in ANILCA Congress set aside another 5.5 million acres of the Tongass wilderness and found that this additional wilderness set aside represents "a proper balance between the reservation of national conservation system units and those public lands necessary and appropriate for more intensive use and disposition" and that no additional conservation areas will be needed in the future on the Tongass. *Id.* Congress attempted to prevent the Executive Branch from circumventing this directive by prohibiting "future executive branch action which withdraws more than five thousand acres, in the aggregate, of public lands within the State of Alaska" without the approval of Congress. 16 U.S.C. §3213(a).

There is a fine line between the USDA's statement in the 2003 ROD that the Tongass Exemption implements "the letter and spirit of congressional direction" and the State's legal argument in the current litigation that by failing to exempt the Tongass from the Roadless Rule USDA has violated ANILCA by withdrawing millions of acres from

more intensive use without the consent of Congress. State Roadless Rule Brief, Ex.4 at 43-44. USDA may view exempting the Tongass as policy to implement the letter and the spirit of congressional direction in ANILCA or as a legal mandate to comply with ANILCA. Either way, complying with congressional intent as set forth in ANILCA is a powerful rationale for a new rulemaking to restore the Tongass Exemption.

The TTRA presents a similar rationale for a new rulemaking. In 1990, Congress amended ANILCA with the TTRA, which included a directive to the USDA Secretary to "seek to provide a supply of timber from the Tongass National Forest, which (1) meets the annual market demand for timber and (2) meets the market demand for timber for each planning cycle" consistent with multiple use and sustained yield management and the requirements of the National Forest Management Act. ROD, Ex.1 at 75142. USDA analyzed the demand numbers for the Tongass timber and the effect of the road construction and timber harvest prohibitions of the Roadless Rule and concluded that "the roadless prohibitions operate as an unnecessary and complicating factor limiting where timber harvesting may occur." *Id.* at 75141.

The State fully concurs with the USDA policy decision that further timber harvest restrictions were not necessary and complicated compliance with the TTRA directive to seek to meet timber demand. However, as with ANILCA, the State continues to argue in federal court that the timber harvest and road construction restrictions of the Roadless Rule limit the ability of the Tongass Forest Supervisor to plan and execute timber sales to the extent that it is impossible to even seek to meet timber demand. Intentionally tying your own agency's hands with such unnecessary restrictions that ensure failure to meet timber demands is a violation of the TTRA provisions to seek to meet demand. The State's full argument why the TTRA legally mandates a Tongass Exemption from the Roadless Rule is presented in the State Roadless Rule Brief, Ex. 4 at 38-43.

As with ANILCA, in 2003 USDA viewed an exemption as policy to implement the letter and the spirit of TTRA while the State determined that TTRA legally mandates an exemption. But again, implementing the directive of Congress is a powerful rationale for a new rulemaking under either analysis.

C. Compelling Case for Exemption Rulemaking

Addressing the serious socioeconomic consequences to Alaskans and complying with ANILCA and TTRA are all compelling rationale for a Tongass Exemption today, as they were in 2003. Other rationales offered by USDA in the 2003 ROD and supported by counsel in the 2010 USDA brief also remain valid today. As noted above, the Ninth Circuit did not invalidate the Tongass Exemption due to flawed rationales, but rather only because of an inadequate explanation for the change in policy. The State respectfully

submits this petition for a rulemaking to exempt the Tongass from the Roadless Rule in the interest of the socioeconomic well-being of its residents.

IV. CONTENT OF REQUESTED RULE

The Tongass Exemption Rule that was invalidated by the Ninth Circuit was a single sentence under 36 CFR § 294.14. The invalidated language in CFR § 294.14 can be replaced by new similar language as simple as: "This subpart does not apply to the Tongass National Forest."

V. OTHER REQUESTED ACTION

In 2016, the USFS completed an extensive amendment process to the TLMP. Among the changes that were made to the TLMP, significant changes included the implementation of the Roadless Rule and the implementation of the Transition Strategy intended to rapidly shift timber harvest in the Tongass from primarily old-growth to young-growth timber. The State was among many objectors to this TLMP amendment based on a wide range of procedural issues and substantive issues in forestry, transportation and resource development. The State's August 30, 2016 formal objection to the 2016 TLMP amendment is attached as Exhibit F. The exhibits filed with the objection can be accessed on the USFS Tongass website at:

https://cloudvault.usda.gov/index.php/s/l6mv9KpoJk90wUa.

The State's objections did not result in changes to the final TLMP.

In addition to requesting that USDA commence a rulemaking to exempt the Tongass from the Roadless Rule, the State also requests that the USDA Secretary direct the USFS to commence a new amendment or revision process for the TLMP as amended in 2016. The State asks that this new TLMP process reconsider all of the objections in the State's objection letter in Exhibit 6. However, section III "The Amended Forest Plan violates the TTRA and ANILCA" is of particular relevance to this petition. Ex. 6 at 6.

This section explains that the Roadless Rule violates both the TTRA and ANILCA as is also discussed above. *Id.* It also explains that in adopting this TLMP amendment "USFS now compounds this violation of federal law by selecting an alternative that not only fully implements the Roadless Rule in the management plan governing the Tongass, but also implements a transition plan to young-growth timber with a rapid phase out of the old-growth timber on which the timber industry is dependent." *Id.*

As a result of implementing the Roadless Rule restrictions in the TLMP, along with additional restrictions on old-growth timber harvest outside of roadless areas, a new

Tongass Exemption rule alone will not provide relief to Southeast Alaska. The Roadless Rule and the 2016 TLMP now each independently restrict road construction and timber harvest to such a degree as to have devastating socioeconomic effects on Alaskans. A more complete discussion of the effects of the TLMP on Alaska and the reasons why the TLMP violates TTRA and ANILCA are set forth in Exhibit 6.

VI. CONCLUSION

Beginning in 2003, USDA has recognized that roadless values in the Tongass are well protected without the Roadless Rule. USDA has also recognized that the prohibitions on road construction and timber harvest in the Roadless Rule come with severe socioeconomic consequences to Alaskans that outweigh any value of adding unnecessary restrictions to those already in place. With this understanding, USDA exempted the Tongass from the Roadless Rule from 2003 until 2011 when a federal court invalidated the Exemption based on a procedural flaw in the 2003 ROD. During this court battle, USDA fully defended USDA's above stated rationale for the exemption.

Subsequent to the court imposing the Roadless Rule on the Tongass, the situation has only been compounded by the USFS's incorporation of the restrictions on roadbuilding and timber harvest into the TLMP. Therefore, both an exemption rulemaking and a TLMP plan revision or amendment are now necessary to reinstate USDA's policy of Tongass exemption set forth in the 2003 ROD.

For the reasons set forth above, the State of Alaska respectfully requests that this petition for rulemaking be granted and that the USDA promptly commences a rulemaking proposing a rule to permanently exempt the Tongass National Forest from application of the Roadless Rule. The State also requests that the Secretary of Agriculture direct the USFS to commence a TLMP revision or amendment to remove provisions of the Roadless Rule that have been incorporated into the plan and to reconsider the State objections set forth in Ex. 6 that were not addressed in the final TLMP.

Respectfully submitted,

Andrew Mack

Andrew T. Mack, Commissioner
State of Alaska, Department of Natural Resources
550 West Seventh Avenue, suite 1400
Anchorage, AK 99501-3561
907.269.8431
andy.mack@alaska.gov

LETTER

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Rate of tree carbon accumulation increases continuously with tree size

N. L. Stephenson[1], A. J. Das[1], R. Condit[2], S. E. Russo[3], P. J. Baker[4], N. G. Beckman[3]†, D. A. Coomes[5], E. R. Lines[6], W. K. Morris[7], N. Rüger[2,8]†, E. Álvarez[9], C. Blundo[10], S. Bunyavejchewin[11], G. Chuyong[12], S. J. Davies[13], Á. Duque[14], C. N. Ewango[15], O. Flores[16], J. F. Franklin[17], H. R. Grau[10], Z. Hao[18], M. E. Harmon[19], S. P. Hubbell[2,20], D. Kenfack[13], Y. Lin[21], J.-R. Makana[15], A. Malizia[10], L. R. Malizia[22], R. J. Pabst[19], N. Pongpattananurak[23], S.-H. Su[24], I-F. Sun[25], S. Tan[26], D. Thomas[27], P. J. van Mantgem[28], X. Wang[18], S. K. Wiser[29] & M. A. Zavala[30]

Forests are major components of the global carbon cycle, providing substantial feedback to atmospheric greenhouse gas concentrations[1]. Our ability to understand and predict changes in the forest carbon cycle—particularly net primary productivity and carbon storage—increasingly relies on models that represent biological processes across several scales of biological organization, from tree leaves to forest stands[2,3]. Yet, despite advances in our understanding of productivity at the scales of leaves and stands, no consensus exists about the nature of productivity at the scale of the individual tree[4–7], in part because we lack a broad empirical assessment of whether rates of absolute tree mass growth (and thus carbon accumulation) decrease, remain constant, or increase as trees increase in size and age. Here we present a global analysis of 403 tropical and temperate tree species, showing that for most species mass growth rate increases continuously with tree size. Thus, large, old trees do not act simply as senescent carbon reservoirs but actively fix large amounts of carbon compared to smaller trees; at the extreme, a single big tree can add the same amount of carbon to the forest within a year as is contained in an entire mid-sized tree. The apparent paradoxes of individual tree growth increasing with tree size despite declining leaf-level[8–10] and stand-level[10] productivity can be explained, respectively, by increases in a tree's total leaf area that outpace declines in productivity per unit of leaf area and, among other factors, age-related reductions in population density. Our results resolve conflicting assumptions about the nature of tree growth, inform efforts to understand and model forest carbon dynamics, and have additional implications for theories of resource allocation[11] and plant senescence[12].

A widely held assumption is that after an initial period of increasing growth, the mass growth rate of individual trees declines with increasing tree size[4,5,13–16]. Although the results of a few single-species studies have been consistent with this assumption[15], the bulk of evidence cited in support of declining growth is not based on measurements of individual tree mass growth. Instead, much of the cited evidence documents either the well-known age-related decline in net primary productivity (hereafter 'productivity') of even-aged forest stands[10] (in which the trees are all of a similar age) or size-related declines in the rate of mass gain per unit leaf area (or unit leaf mass)[8–10], with the implicit assumption that declines at these scales must also apply at the scale of the individual tree. Declining tree growth is also sometimes inferred from life-history theory to be a necessary corollary of increasing resource allocation to reproduction[11,16]. On the other hand, metabolic scaling theory predicts that mass growth rate should increase continuously with tree size[6], and this prediction has also received empirical support from a few site-specific studies[6,7]. Thus, we are confronted with two conflicting generalizations about the fundamental nature of tree growth, but lack a global assessment that would allow us to distinguish clearly between them.

To fill this gap, we conducted a global analysis in which we directly estimated mass growth rates from repeated measurements of 673,046 trees belonging to 403 tropical, subtropical and temperate tree species, spanning every forested continent. Tree growth rate was modelled as a function of log(tree mass) using piecewise regression, where the independent variable was divided into one to four bins. Conjoined line segments were fitted across the bins (Fig. 1).

For all continents, aboveground tree mass growth rates (and, hence, rates of carbon gain) for most species increased continuously with tree mass (size) (Fig. 2). The rate of mass gain increased with tree mass in each model bin for 87% of species, and increased in the bin that included the largest trees for 97% of species; the majority of increases were statistically significant (Table 1, Extended Data Fig. 1 and Supplementary Table 1). Even when we restricted our analysis to species achieving the largest sizes (maximum trunk diameter >100 cm; 33% of species), 94% had increasing mass growth rates in the bin that included the largest trees. We found no clear taxonomic or geographic patterns among the 3% of species with declining growth rates in their largest trees, although the small number of these species (thirteen) hampers inference. Declining species included both angiosperms and gymnosperms in seven of the 76 families in our study; most of the seven families had only one or two declining species and no family was dominated by declining species (Supplementary Table 1).

When we log-transformed mass growth rate in addition to tree mass, the resulting model fits were generally linear, as predicted by metabolic scaling theory[6] (Extended Data Fig. 2). Similar to the results of our main

[1]US Geological Survey, Western Ecological Research Center, Three Rivers, California 93271, USA. [2]Smithsonian Tropical Research Institute, Apartado 0843-03092, Balboa, Republic of Panama. [3]School of Biological Sciences, University of Nebraska, Lincoln, Nebraska 68588, USA. [4]Department of Forest and Ecosystem Science, University of Melbourne, Victoria 3121, Australia. [5]Department of Plant Sciences, University of Cambridge, Cambridge CB2 3EA, UK. [6]Department of Geography, University College London, London WC1E 6BT, UK. [7]School of Botany, University of Melbourne, Victoria 3010, Australia. [8]Spezielle Botanik und Funktionelle Biodiversität, Universität Leipzig, 04103 Leipzig, Germany. [9]Jardín Botánico de Medellín, Calle 73, No. 51D-14, Medellín, Colombia. [10]Instituto de Ecología Regional, Universidad Nacional de Tucumán, 4107 Yerba Buena, Tucumán, Argentina. [11]Research Office, Department of National Parks, Wildlife and Plant Conservation, Bangkok 10900, Thailand. [12]Department of Botany and Plant Physiology, Buea, Southwest Province, Cameroon. [13]Smithsonian Institution Global Earth Observatory—Center for Tropical Forest Science, Smithsonian Institution, PO Box 37012, Washington, DC 20013, USA. [14]Universidad Nacional de Colombia, Departamento de Ciencias Forestales, Medellín, Colombia. [15]Wildlife Conservation Society, Kinshasa/Gombe, Democratic Republic of the Congo. [16]Unité Mixte de Recherche—Peuplements Végétaux et Bioagresseurs en Milieu Tropical, Université de la Réunion/CIRAD, 97410 Saint Pierre, France. [17]School of Environmental and Forest Sciences, University of Washington, Seattle, Washington 98195, USA. [18]State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, China. [19]Department of Forest Ecosystems and Society, Oregon State University, Corvallis, Oregon 97331, USA. [20]Department of Ecology and Evolutionary Biology, University of California, Los Angeles, California 90095, USA. [21]Department of Life Science, Tunghai University, Taichung City 40704, Taiwan. [22]Facultad de Ciencias Agrarias, Universidad Nacional de Jujuy, 4600 San Salvador de Jujuy, Argentina. [23]Faculty of Forestry, Kasetsart University, ChatuChak Bangkok 10900, Thailand. [24]Taiwan Forestry Research Institute, Taipei 10066, Taiwan. [25]Department of Natural Resources and Environmental Studies, National Dong Hwa University, Hualien 97401, Taiwan. [26]Sarawak Forestry Department, Kuching, Sarawak 93660, Malaysia. [27]Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331, USA. [28]US Geological Survey, Western Ecological Research Center, Arcata, California 95521, USA. [29]Landcare Research, PO Box 40, Lincoln 7640, New Zealand. [30]Forest Ecology and Restoration Group, Department of Life Sciences, University of Alcalá, Alcalá de Henares, 28805 Madrid, Spain. †Present addresses: Mathematical Biosciences Institute, Ohio State University, Columbus, Ohio 43210, USA (N.G.B.); German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, 04103 Leipzig, Germany (N.R.).

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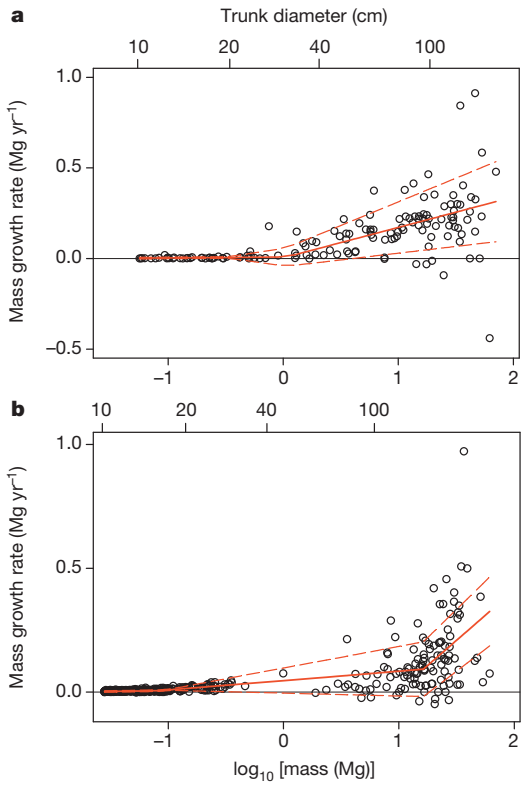

Figure 1 | Example model fits for tree mass growth rates. The species shown are the angiosperm species (*Lecomtedoxa klaineana*, Cameroon, 142 trees) (**a**) and gymnosperm species (*Picea sitchensis*, USA, 409 trees) (**b**) in our data set that had the most massive trees (defined as those with the greatest cumulative aboveground dry mass in their five most massive trees). Each point represents a single tree; the solid red lines represent best fits selected by our model; and the dashed red lines indicate one standard deviation around the predicted values.

analysis using untransformed growth, of the 381 log-transformed species analysed (see Methods), the log-transformed growth rate increased in the bin containing the largest trees for 96% of species.

In absolute terms, trees 100 cm in trunk diameter typically add from 10 kg to 200 kg of aboveground dry mass each year (depending on species), averaging 103 kg per year. This is nearly three times the rate for trees of the same species at 50 cm in diameter, and is the mass equivalent to adding an entirely new tree of 10–20 cm in diameter to the forest each year. Our findings further indicate that the extraordinary growth recently reported in an intensive study of large *Eucalyptus regnans* and *Sequoia sempervirens*[7], which included some of the world's most massive individual trees, is not a phenomenon limited to a few unusual species. Rather, rapid growth in giant trees is the global norm, and can exceed 600 kg per year in the largest individuals (Fig. 3).

Our data set included many natural and unmanaged forests in which the growth of smaller trees was probably reduced by asymmetric competition with larger trees. To explore the effects of competition, we calculated mass growth rates for 41 North American and European species that had published equations for diameter growth rate in the absence of competition. We found that, even in the absence of competition, 85% of the species had mass growth rates that increased continuously with tree size (Extended Data Fig. 3), with growth curves closely resembling those in Fig. 2. Thus, our finding of increasing growth not only has broad generality across species, continents and forest biomes (tropical, subtropical and temperate), it appears to hold regardless of competitive environment.

Importantly, our finding of continuously increasing growth is compatible with the two classes of observations most often cited as evidence of declining, rather than increasing, individual tree growth: with increasing tree size and age, productivity usually declines at the scales of both tree organs (leaves) and tree populations (even-aged forest stands).

First, although growth efficiency (tree mass growth per unit leaf area or leaf mass) often declines with increasing tree size[8–10], empirical observations and metabolic scaling theory both indicate that, on average, total tree leaf mass increases as the square of trunk diameter[17,18]. A typical tree that experiences a tenfold increase in diameter will therefore undergo a roughly 100-fold increase in total leaf mass and a 50–100-fold

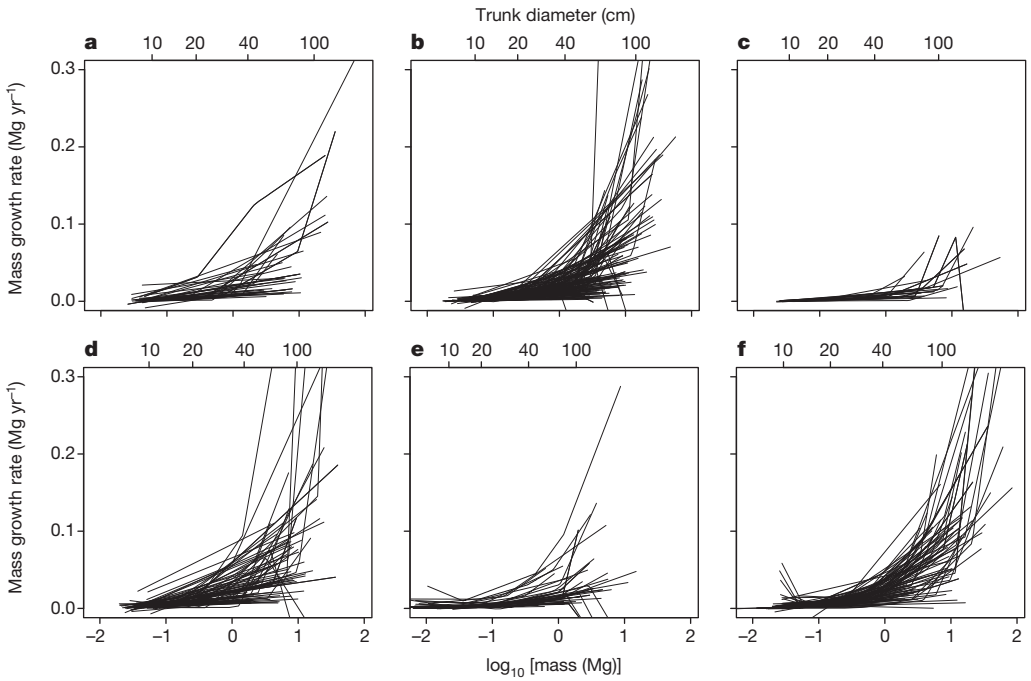

Figure 2 | Aboveground mass growth rates for the 403 tree species, by continent. **a**, Africa (Cameroon, Democratic Republic of the Congo); **b**, Asia (China, Malaysia, Taiwan, Thailand); **c**, Australasia (New Zealand); **d**, Central and South America (Argentina, Colombia, Panama); **e**, Europe (Spain); and **f**, North America (USA). Numbers of trees, numbers of species and percentages with increasing growth are given in Table 1. Trunk diameters are approximate values for reference, based on the average diameters of trees of a given mass.

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Table 1 | Sample sizes and tree growth trends by continent

Continent	Number of trees	Number of species	Percentage of species with increasing mass growth rate in the largest trees (percentage significant at $P \leq 0.05$)
Africa	15,366	37	100.0 (86.5)
Asia	43,690	136	96.3 (89.0)
Australasia	45,418	22	95.5 (95.5)
Central and South America	18,530	77	97.4 (92.2)
Europe	439,889	42	90.5 (78.6)
North America	110,153	89	98.9 (94.4)
Total	673,046	403	96.8 (89.8)

The largest trees are those in the last bin fitted by the model. Countries are listed in the legend for Fig. 2.

increase in total leaf area (depending on size-related increases in leaf mass per unit leaf area[19,20]). Parallel changes in growth efficiency can range from a modest increase (such as in stands where small trees are suppressed by large trees)[21] to as much as a tenfold decline[22], with most changes falling in between[8,9,19,22]. At one extreme, the net effect of a low (50-fold) increase in leaf area combined with a large (tenfold) decline in growth efficiency would still yield a fivefold increase in individual tree mass growth rate; the opposite extreme would yield roughly a 100-fold increase. Our calculated 52-fold greater average mass growth rate of trees 100 cm in diameter compared to those 10 cm in diameter falls within this range. Thus, although growth efficiency often declines with increasing tree size, increases in a tree's total leaf area are sufficient to overcome this decline and cause whole-tree carbon accumulation rate to increase.

Second, our findings are similarly compatible with the well-known age-related decline in productivity at the scale of even-aged forest stands. Although a review of mechanisms is beyond the scope of this paper[10,23], several factors (including the interplay of changing growth efficiency and tree dominance hierarchies[24]) can contribute to declining productivity at the stand scale. We highlight the fact that increasing individual tree growth rate does not automatically result in increasing stand productivity because tree mortality can drive orders-of-magnitude reductions in population density[25,26]. That is, even though the large trees in older, even-aged stands may be growing more rapidly, such stands have fewer trees. Tree population dynamics, especially mortality, can thus be a significant contributor to declining productivity at the scale of the forest stand[23].

For a large majority of species, our findings support metabolic scaling theory's qualitative prediction of continuously increasing growth at the scale of individual trees[6], with several implications. For example, life-history theory often assumes that tradeoffs between plant growth and reproduction are substantial[11]. Contrary to some expectations[11,16], our results indicate that for most tree species size-related changes in reproductive allocation are insufficient to drive long-term declines in growth rates[6]. Additionally, declining growth is sometimes considered to be a defining feature of plant senescence[12]. Our findings are thus relevant to understanding the nature and prevalence of senescence in the life history of perennial plants[27].

Finally, our results are relevant to understanding and predicting forest feedbacks to the terrestrial carbon cycle and global climate system[1–3]. These feedbacks will be influenced by the effects of climatic, land-use and other environmental changes on the size-specific growth rates and size structure of tree populations—effects that are already being observed in forests[28,29]. The rapid growth of large trees indicates that, relative to their numbers, they could play a disproportionately important role in these feedbacks[30]. For example, in our western USA old-growth forest plots, trees >100 cm in diameter comprised 6% of trees, yet contributed 33% of the annual forest mass growth. Mechanistic models of the forest carbon cycle will depend on accurate representation of productivity across several scales of biological organization, including calibration and validation against continuously increasing carbon accumulation rates at the scale of individual trees.

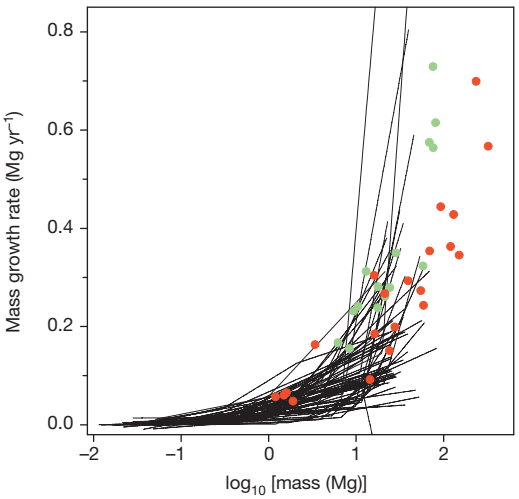

Figure 3 | Aboveground mass growth rates of species in our data set compared with *E. regnans* and *S. sempervirens*. For clarity, only the 58 species in our data set having at least one tree exceeding 20 Mg are shown (lines). Data for *E. regnans* (green dots, 15 trees) and *S. sempervirens* (red dots, 21 trees) are from an intensive study that included some of the most massive individual trees on Earth[7]. Both axes are expanded relative to those of Fig. 2.

METHODS SUMMARY

We estimated aboveground dry mass growth rates from consecutive diameter measurements of tree trunks—typically measured every five to ten years—from long-term monitoring plots. Analyses were restricted to trees with trunk diameter ≥10 cm, and to species having ≥40 trees in total and ≥15 trees with trunk diameter ≥30 cm. Maximum trunk diameters ranged from 38 cm to 270 cm among species, averaging 92 cm. We converted each diameter measurement (plus an accompanying height measurement for 16% of species) to aboveground dry mass, M, using published allometric equations. We estimated tree growth rate as $G = \Delta M/\Delta t$ and modelled G as a function of $\log(M)$ for each species using piecewise regression. The independent variable $\log(M)$ was divided into bins and a separate line segment was fitted to G versus $\log(M)$ in each bin so that the line segments met at the bin divisions. Bin divisions were not assigned a priori, but were fitted by the model separately for each species. We fitted models with 1, 2, 3 and 4 bins, and selected the model receiving the most support by Akaike's Information Criterion for each species. Our approach thus makes no assumptions about the shape of the relationship between G and $\log(M)$, and can accommodate increasing, decreasing or hump-shaped relationships. Parameters were fitted with a Gibbs sampler based on Metropolis updates, producing credible intervals for model parameters and growth rates at any diameter; uninformative priors were used for all parameters. We tested extensively for bias, and found no evidence that our results were influenced by model fits failing to detect a final growth decline in the largest trees, possible biases introduced by the 47% of species for which we combined data from several plots, or possible biases introduced by allometric equations (Extended Data Figs 4 and 5).

Online Content Any additional Methods, Extended Data display items and Source Data are available in the online version of the paper; references unique to these sections appear only in the online paper.

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Supplementary Information is available in the online version of the paper.

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Author Contributions N.L.S. and A.J.D. conceived the study with feedback from R.C. and D.A.C., N.L.S., A.J.D., R.C. and S.E.R. wrote the manuscript. R.C. devised the main analytical approach and wrote the computer code. N.L.S., A.J.D., R.C., S.E.R., P.J.B., N.G.B., D.A.C., E.R.L., W.K.M. and N.R. performed analyses. N.L.S., A.J.D., R.C., S.E.R., P.J.B., D.A.C., E.R.L., W.K.M., E.Á., C.B., S.B., G.C., S.J.D., Á.D., C.N.E., O.F., J.F.F., H.R.G., Z.H., M.E.H., S.P.H., D.K., Y.L., J.-R.M., A.M., L.R.M., R.J.P., N.P., S.-H.S., I-F.S., S.T., D.T., P.J.v.M., X.W., S.K.W. and M.A.Z. supplied data and sources of allometric equations appropriate to their data.

Author Information Fitted model parameters for each species have been deposited in USGS's ScienceBase at http://dx.doi.org/10.5066/F7JS9NFM. Reprints and permissions information is available at www.nature.com/reprints. The authors declare no competing financial interests. Readers are welcome to comment on the online version of the paper. Correspondence and requests for materials should be addressed to N.L.S. (nstephenson@usgs.gov).

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METHODS

Data. We required that forest monitoring plots provided unbiased samples of all living trees within the plot boundaries, and that the trees had undergone two trunk diameter measurements separated by at least one year. Some plots sampled minimally disturbed old (all-aged) forest, whereas others, particularly those associated with national inventories, sampled forest stands regardless of past management history. Plots are described in the references cited in Supplementary Table 1.

Our raw data were consecutive measurements of trunk diameter, D, with most measurements taken 5 to 10 years apart (range, 1–29 years). D was measured at a standard height on the trunk (usually 1.3–1.4 m above ground level), consistent across measurements for a tree. Allometric equations for 16% of species required, in addition to consecutive measurements of D, consecutive measurements of tree height.

We excluded trees exhibiting extreme diameter growth, defined as trunks where D increased by $\geq 40\ \mathrm{mm\,yr^{-1}}$ or that shrank by $\geq 12s$, where s is the standard deviation of the D measurement error, $s = 0.9036 + 0.006214D$ (refs 31, 32); outliers of these magnitudes were almost certainly due to error. By being so liberal in allowing negative growth anomalies, we erred on the side of reducing our ability to detect increases in tree mass growth rate. Using other exclusion values yielded similar results, as did a second approach to handling error in which we reanalysed a subset of our models using a Bayesian method that estimates growth rates after accounting for error, based on independent plot-specific data quantifying measurement error[33].

To standardize minimum D among data sets, we analysed only trees with $D \geq 10$ cm at the first census. To ensure adequate samples of trees spanning a broad range of sizes, we restricted analyses to species having both ≥ 40 trees in total and also ≥ 15 trees with $D \geq 30$ cm at the first census. This left us with 673,046 trees belonging to 403 tropical and temperate species in 76 families, spanning twelve countries and all forested continents (Supplementary Table 1). Maximum trunk diameters ranged from 38 cm to 270 cm among species, and averaged 92 cm.

Estimating tree mass. To estimate each tree's aboveground dry mass, M, we used published allometric equations relating M to D (or for 16% of species, relating M to D and tree height). Some equations were species-specific and others were specific to higher taxonomic levels or forest types, described in the references in Supplementary Table 1. The single tropical moist forest equation of ref. 34 was applied to most tropical species, whereas most temperate species had unique species-specific equations. Most allometric equations are broadly similar, relating $\log(M)$ to $\log(D)$ linearly, or nearly linearly—a familiar relationship in allometric scaling of both animals and plants[35]. Equations can show a variety of differences in detail, however, with some adding $\log(D)$ squared and cubed terms. All equations make use of the wood density of individual species, but when wood density was not available for a given species we used mean wood density for a genus or family[36].

Using a single, average allometry for most tropical species, and mean wood density for a genus or family for several species, limits the accuracy of our estimates of M. However, because we treat each species separately, it makes no difference whether our absolute M estimates are more accurate in some species than in others, only that they are consistent within a species and therefore accurately reveal whether mass growth rates increase or decrease with tree size.

For two regions—Spain and the western USA—allometric equations estimated mass only for a tree's main stem rather than all aboveground parts, including branches and leaves. But because leaf and stem masses are positively correlated and their growth rates are expected to scale isometrically both within and among species[18,37,38], results from these two regions should not alter our qualitative conclusions. Confirming this, the percentage of species with increasing stem mass growth rate in the last bin for Spain and the western USA (93.4% of 61 species) was similar to that from the remainder of regions (97.4% of 342 species) ($P = 0.12$, Fisher's exact test).

Modelling mass growth rate. We sought a modelling approach that made no assumptions about the shape of the relationship between aboveground dry mass growth rate, G, and aboveground dry mass, M, and that could accommodate monotonically increasing, monotonically decreasing, or hump-shaped relationships. We therefore chose to model G as a function of $\log(M)$ using piecewise linear regression. The range of the x axis, $X = \log(M)$, is divided into a series of bins, and within each bin G is fitted as a function of X by linear regression. The position of the bins is adaptive: it is fitted along with the regression terms. Regression lines are required to meet at the boundary between bins. For a single model-fitting run the number of bins, B, is fixed. For example, if $B = 2$, there are four parameters to be fitted for a single species: the location of the boundary between bins, X_1; the slope of the regression in the first bin, S_1; the slope in the second bin, S_2; and an intercept term. Those four parameters completely define the model. In general, there are $2B$ parameters for B bins.

Growth rates, while approximately normally distributed, were heteroskedastic, with the variance increasing with mass (Fig. 1), so an additional model was needed for the standard deviation of G, σ_G, as a function of $\log(M)$. The increase of σ_G with $\log(M)$ was clearly not linear, so we used a three-parameter model:

$$\sigma_G = k \qquad (\text{for } \log(M) < d)$$

$$\sigma_G = a + b\log(M) \qquad (\text{for } \log(M) \geq d)$$

where the intercept a is determined by the values of k, d and b. Thus σ_G was constant for smaller values of $\log(M)$ (below the cutoff d), then increased linearly for larger $\log(M)$ (Fig. 1). The parameters k, d and b were estimated along with the parameters of the growth model.

Parameters of both the growth and standard deviation models were estimated in a Bayesian framework using the likelihood of observing growth rates given model predictions and the estimated standard deviation of the Gaussian error function. A Markov chain Monte Carlo chain of parameter estimates was created using a Gibbs sampler with a Metropolis update[39,40] written in the programming language R (ref. 41) (a tutorial and the computer code are available through http://ctfs.arnarb.harvard.edu/Public/CTFSRPackage/files/tutorials/growthfitAnalysis). The sampler works by updating each of the parameters in sequence, holding other parameters fixed while the relevant likelihood function is used to locate the target parameter's next value. The step size used in the updates was adjusted adaptively through the runs, allowing more rapid convergence[40]. The final Markov chain Monte Carlo chain describes the posterior distribution for each model parameter, the error, and was then used to estimate the posterior distribution of growth rates as estimated from the model. Priors on model parameters were uniform over an unlimited range, whereas the parameters describing the standard deviation were restricted to >0. Bin boundaries, X_i, were constrained as follows: (1) boundaries could only fall within the range of X, (2) each bin contained at least five trees, and (3) no bin spanned less than 10% of the range of X. The last two restrictions prevented the bins from collapsing to very narrow ranges of X in which the fitted slope might take absurd extremes.

We chose piecewise regression over other alternatives for modelling G as a function of M for two main reasons. First, the linear regression slopes within each bin provide precise statistical tests of whether G increases or decreases with X, based on credible intervals of the slope parameters. Second, with adaptive bin positions, the function is completely flexible in allowing changes in slope at any point in the X range, with no influence of any one bin on the others. In contrast, in parametric models where a single function defines the relationship across all X, the shape of the curve at low X can (and indeed must) influence the shape at high X, hindering statistical inference about changes in tree growth at large size.

We used $\log(M)$ as our predictor because within a species M has a highly non-Gaussian distribution, with many small trees and only a few very large trees, including some large outliers. In contrast, we did not log-transform our dependent variable G so that we could retain values of $G \leq 0$ that are often recorded in very slowly growing trees, for which diameter change over a short measurement interval can be on a par with diameter measurement error.

For each species, models with 1, 2, 3 and 4 bins were fitted. Of these four models, the model receiving the greatest weight of evidence by Akaike Information Criterion (AIC) was selected. AIC is defined as the log-likelihood of the best-fitting model, penalized by twice the number of parameters. Given that adding one more bin to a model meant two more parameters, the model with an extra bin had to improve the log-likelihood by 4 to be considered a better model[42].

Assessing model fits. To determine whether our approach might have failed to reveal a final growth decline within the few largest trees of the various species, we calculated mass growth rate residuals for the single most massive individual tree of each species. For 52% of the 403 species, growth of the most massive tree was underestimated by our model fits (for example, Fig. 1a); for 48% it was overestimated (for example, Fig. 1b). These proportions were indistinguishable from 50% ($P = 0.55$, binomial test), as would be expected for unbiased model fits. Furthermore, the mean residual (observed minus predicted) mass growth rate of these most massive trees, $+0.006\ \mathrm{Mg\,yr^{-1}}$, was statistically indistinguishable from zero ($P = 0.29$, two-tailed t-test). We conclude that our model fits accurately represent growth trends up through, and including, the most massive trees.

Effects of combined data. To achieve sample sizes adequate for analysis, for some species we combined data from several different forest plots, potentially introducing a source of bias: if the largest trees of a species disproportionately occur on productive sites, the increase in mass growth rate with tree size could be exaggerated. This might occur because trees on less-productive sites—presumably the sites having the slowest-growing trees within any given size class—could be under-represented in the largest size classes. We assessed this possibility in two ways.

First, our conclusions remained unchanged when we compared results for the 53% of species that came uniquely from single large plots with those of the 47% of species whose data were combined across several plots. Proportions of species with increasing mass growth rates in the last bin were indistinguishable between the two groups (97.6% and 95.8%, respectively; $P = 0.40$, Fisher's exact test). Additionally,

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the shapes and magnitudes of the growth curves for Africa and Asia, where data for each species came uniquely from single large plots, were similar to those of Australasia, Europe and North America, where data for each species were combined across several plots (Table 1, Fig. 2 and Extended Data Fig. 2). (Data from Central and South America were from both single and combined plots, depending on species.)

Second, for a subset of combined-data species we compared two sets of model fits: (1) using all available plots (that is, the analyses we present in the main text), and (2) using only plots that contained massive trees—those in the top 5% of mass for a species. To maximize our ability to detect differences, we limited these analyses to species with large numbers of trees found in a large number of plots, dispersed widely across a broad geographic region. We therefore analysed the twelve Spanish species that each had more than 10,000 individual trees (Supplementary Table 1), found in 34,580 plots distributed across Spain. Massive trees occurred in 6,588 (19%) of the 34,580 plots. We found no substantial differences between the two analyses. When all 34,580 plots were analysed, ten of the twelve species showed increasing growth in the last bin, and seven showed increasing growth across all bins; when only the 6,588 plots containing the most massive trees were analysed, the corresponding numbers were eleven and nine. Model fits for the two groups were nearly indistinguishable in shape and magnitude across the range of tree masses. We thus found no evidence that the potential for growth differences among plots influenced our conclusions.

Effects of possible allometric biases. For some species, the maximum trunk diameter D in our data sets exceeded the maximum used to calibrate the species' allometric equation. In such cases our estimates of M extrapolate beyond the fitted allometry and could therefore be subject to bias. For 336 of our 403 species we were able to determine D of the largest tree that had been used in calibrating the associated allometric equations. Of those 336 species, 74% (dominated by tropical species) had no trees in our data set with D exceeding that used in calibrating the allometric equations, with the remaining 26% (dominated by temperate species) having at least one tree with D exceeding that used in calibration. The percentage of species with increasing G in the last bin for the first group (98.0%) was indistinguishable from that of the second group (96.6%) ($P = 0.44$, Fisher's exact test). Thus, our finding of increasing G with tree size is not affected by the minority of species that have at least one tree exceeding the maximum value of D used to calibrate their associated allometric equations.

A bias that could inflate the rate at which G increases with tree size could arise if allometric equations systematically underestimate M for small trees or overestimate M for large trees[43]. For a subset of our study species we obtained the raw data—consisting of measured values of D and M for individual trees—needed to calibrate allometric equations, allowing us to determine whether the particular form of those species' allometric equations was prone to bias, and if so, the potential consequences of that bias.

To assess the potential for allometric bias for the majority (58%) of species in our data set—those that used the empirical moist tropical forest equation of ref. 34—we reanalysed the data provided by ref. 34. The data were from 1,504 harvested trees representing 60 families and 184 genera, with D ranging from 5 cm to 156 cm; the associated allometric equation relates $\log(M)$ to a third-order polynomial of $\log(D)$. Because the regression of M on D was fitted on a log–log scale, this and subsequent equations include a correction of $\exp[(\mathrm{RSE})^2/2]$ for the error in back-transformation, where RSE is the residual standard error from the statistical model[44]. Residuals of M for the equation revealed no evident biases (Extended Data Fig. 4a), suggesting that we should expect little (if any) systematic size-related biases in our estimates of G for the 58% of our species that used this equation.

Our simplest form of allometric equation—applied to 22% of our species—was $\log(M) = a + b\log(D)$, where a and b are taxon-specific constants. For nine of our species that used equations of this form (all from the temperate western USA: *Abies amabilis, A. concolor, A. procera, Pinus lambertiana, Pinus ponderosa, Picea sitchensis, Pseudotsuga menziesii, Tsuga heterophylla* and *T. mertensiana*) we had values of both D and M for a total of 1,358 individual trees, allowing us to fit species-specific allometric equations of the form $\log(M) = a + b\log(D)$ and then assess them for bias. Residual plots showed a tendency to overestimate M for the largest trees (Extended Data Fig. 4b), with the possible consequence of inflating estimates of G for the largest relative to the smallest trees of these species.

To determine whether this bias was likely to alter our qualitative conclusion that G increases with tree size, we created a new set of allometric relations between D and M —one for each of the nine species—using the same piecewise linear regression approach we used to model G as a function of M. However, because our goal was to eliminate bias rather than seek the most parsimonious model, we fixed the number of bins at four, with the locations of boundaries between the bins being fitted by the model. Our new allometry using piecewise regressions led to predictions of M with no apparent bias relative to D (Extended Data Fig. 4c). This new, unbiased allometry gave the same qualitative results as our original, simple allometry regarding the relationship between G and M: for all nine species, G increased in the bin containing the largest trees, regardless of the allometry used (Extended Data Fig. 5). We conclude that any bias associated with the minority of our species that used the simple allometric equation form was unlikely to affect our broad conclusion that G increases with tree size in a majority of tree species.

As a final assessment, we compared our results to those of a recent study of *E. regnans* and *S. sempervirens*, in which M and G had been calculated from intensive measurements of aboveground portions of trees without the use of standard allometric equations[7]. Specifically, in two consecutive years 36 trees of different sizes and ages were climbed, trunk diameters were systematically measured at several heights, branch diameters and lengths were measured (with subsets of foliage and branches destructively sampled to determine mass relationships), wood densities were determined and ring widths from increment cores were used to supplement measured diameter growth increments. The authors used these measurements to calculate M for each of the trees in each of the two consecutive years, and G as the difference in M between the two years[7]. *E. regnans* and *S. sempervirens* are the world's tallest angiosperm and gymnosperm species, respectively, so the data set was dominated by exceptionally large trees; most had $M \geq 20$ Mg, and M of some individuals exceeded that of the most massive trees in our own data set (which lacked *E. regnans* and *S. sempervirens*). We therefore compared *E. regnans* and *S. sempervirens* to the 58 species in our data set that had at least one individual with $M \geq 20$ Mg. Sample sizes for *E. regnans* and *S. sempervirens*—15 and 21 trees, respectively—fell below our required ≥40 trees for fitting piecewise linear regressions, so we simply plotted data points for individual *E. regnans* and *S. sempervirens* along with the piecewise regressions that we had already fitted for our 58 comparison species (Fig. 3).

As reported by ref. 7, G increased with M for both *E. regnans* and *S. sempervirens*, up to and including some of the most massive individual trees on the Earth (Fig. 3). Within the zone of overlapping M between the two data sets, G values for individual *E. regnans* and *S. sempervirens* trees fell almost entirely within the ranges of the piecewise regressions we had fitted for our 58 comparison species. We take these observations as a further indication that our results, produced using standard allometric equations, accurately reflect broad relationships between M and G.

Fitting log–log models. To model $\log(G)$ as a function of $\log(M)$, we used the binning approach that we used in our primary analysis of mass growth rate (described earlier). However, in log-transforming growth we dropped trees with $G \leq 0$. Because negative growth rates become more extreme with increasing tree size, dropping them could introduce a bias towards increasing growth rates. Log-transformation additionally resulted in skewed growth rate residuals. Dropping trees with $G \leq 0$ caused several species to fall below our threshold sample size, reducing the total number of species analysed to 381 (Extended Data Fig. 2).

Growth in the absence of competition. We obtained published equations for 41 North American and European species, in 46 species-site combinations, relating species-specific tree diameter growth rates to trunk diameter D and to neighbourhood competition[45–49]. Setting neighbourhood competition to zero gave us equations describing estimated annual D growth as a function of D in the absence of competition. Starting at $D_0 = 10$ cm, we sequentially (1) calculated annual D growth for a tree of size D_t, (2) added this amount to D_t to determine D_{t+1}, (3) used an appropriate taxon-specific allometric equation to calculate the associated tree masses M_t and M_{t+1}, and (iv) calculated tree mass growth rate G_t of a tree of mass M_t in the absence of competition as $M_{t+1} - M_t$. For each of the five species that had separate growth analyses available from two different sites, we required that mass growth rate increased continuously with tree size at both sites for the species to be considered to have a continuously increasing mass growth rate. North American and European allometries were taken from refs 17 and 50, respectively, with preference given to allometric equations based on power functions of tree diameter, large numbers of sampled trees, and trees spanning a broad range of diameters. For the 47% of European species for which ref. 50 had no equations meeting our criteria, we used the best-matched (by species or genus) equations from ref. 17.

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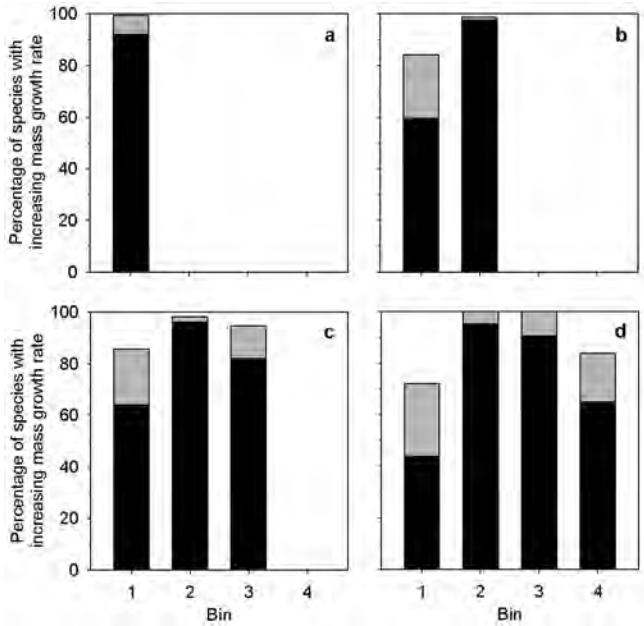

Extended Data Figure 1 | Summary of model fits for tree mass growth rates. Bars show the percentage of species with mass growth rates that increase with tree mass for each bin; black shading indicates percentage significant at $P \leq 0.05$. Tree masses increase with bin number. **a**, Species fitted with one bin (165 species); **b**, Species fitted with two bins (139 species); **c**, Species fitted with three bins (56 species); and **d**, Species fitted with four bins (43 species).

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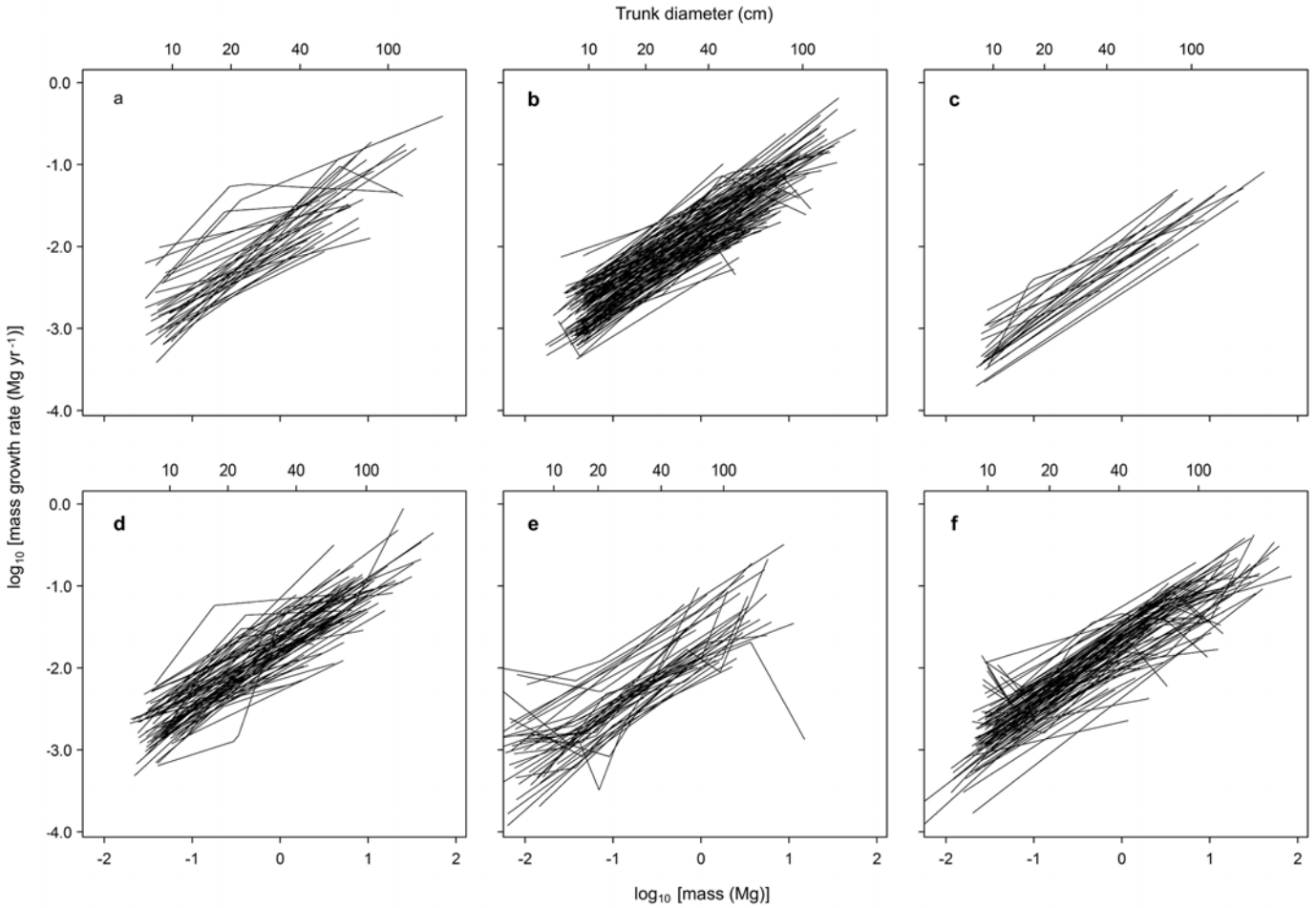

Extended Data Figure 2 | Log–log model fits of mass growth rates for 381 tree species, by continent. Trees with growth rates ≤ 0 were dropped from the analysis, reducing the number of species meeting our threshold sample size for analysis. **a**, Africa (33 species); **b**, Asia (123 species); **c**, Australasia (22 species); **d**, Central and South America (73 species); **e**, Europe (41 species); and **f**, North America (89 species). Trunk diameters are approximate values for reference, based on the average diameters of trees of a given mass.

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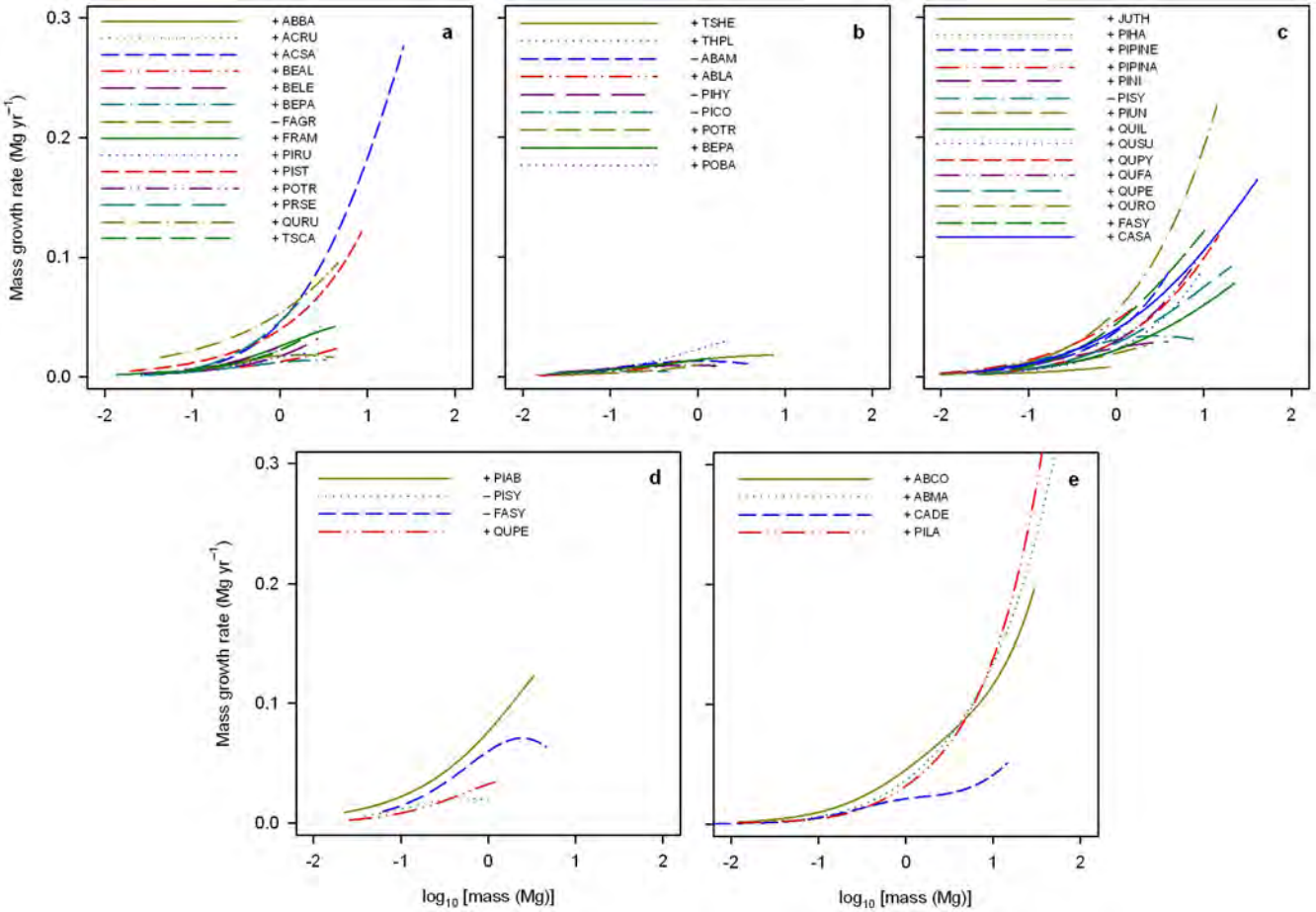

Extended Data Figure 3 | Aboveground mass growth rates for 41 tree species in the absence of competition. The '+' or '−' symbol preceding each species code indicates, respectively, species with mass growth rates that increased continuously with tree size or species with mass growth rates that declined in the largest trees. Sources of the diameter growth equations used to calculate mass growth were: **a**, ref. 45; **b**, ref. 46; **c**, ref. 48; **d**, ref. 47; and **e**, ref. 49. ABAM, *Abies amabilis*; ABBA, *Abies balsamea*; ABCO, *Abies concolor*; ABLA, *Abies lasiocarpa*; ABMA, *Abies magnifica*; ACRU, *Acer rubrum*; ACSA, *Acer saccharum*; BEAL, *Betula alleghaniensis*; BELE, *Betula lenta*; BEPA, *Betula papyrifera*; CADE, *Calocedrus decurrens*; CASA, *Castanea sativa*; FAGR, *Fagus grandifolia*; FASY, *Fagus sylvatica*; FRAM, *Fraxinus americana*; JUTH, *Juniperus thurifera*; PIAB, *Picea abies*; PICO, *Pinus contorta*; PIHA, *Pinus halepensis*; PIHY, *Picea* hybrid (a complex of *Picea glauca*, *P. sitchensis* and *P. engelmannii*); PILA, *Pinus lambertiana*; PINI, *Pinus nigra*; PIPINA, *Pinus pinaster*; PIPINE, *Pinus pinea*; PIRU, *Picea rubens*; PIST, *Pinus strobus*; PISY, *Pinus sylvestris*; PIUN, *Pinus uncinata*; POBA, *Populus balsamifera* ssp. *trichocarpa*; POTR, *Populus tremuloides*; PRSE, *Prunus serotina*; QUFA, *Quercus faginea*; QUIL, *Quercus ilex*; QUPE, *Quercus petraea*; QUPY, *Quercus pyrenaica*; QURO, *Quercus robar*; QURU, *Quercus rubra*; QUSU, *Quercus suber*; THPL, *Thuja plicata*; TSCA, *Tsuga canadensis*; and TSHE, *Tsuga heterophylla*.

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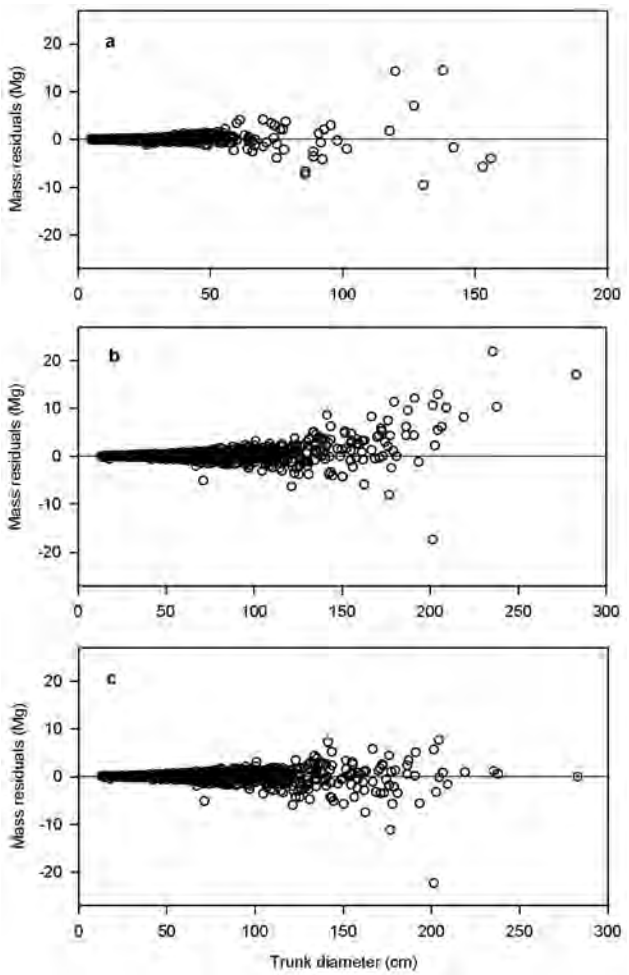

Extended Data Figure 4 | Residuals of predicted minus observed tree mass. **a**, The allometric equation for moist tropical forests[34]—used for the majority of tree species—shows no evident systematic bias in predicted aboveground dry mass, *M*, relative to trunk diameter ($n = 1{,}504$ trees). **b**, In contrast, our simplest form of allometric equation—used for 22% of our species and here applied to nine temperate species—shows an apparent bias towards overestimating *M* for large trees ($n = 1{,}358$ trees). **c**, New allometries that we created for the nine temperate species removed the apparent bias in predicted *M*.

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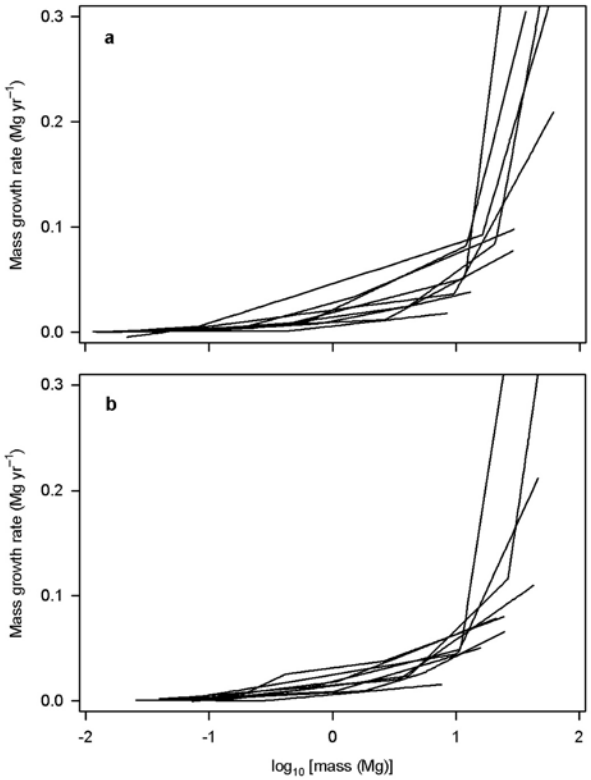

Extended Data Figure 5 | Estimated mass growth rates of the nine temperate species of Extended Data Fig. 4. Growth was estimated using the simplest form of allometric model [$\log(M) = a + b\log(D)$] (**a**) and our allometric models fitted with piecewise linear regression (**b**). Regardless of the allometric model form, all nine species show increasing G in the largest trees.

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Post-glacial colonization of northwestern North America by the forest-associated American marten (*Martes americana*, Mammalia: Carnivora: Mustelidae)

KAREN D. STONE,*†§ RODNEY W. FLYNN‡ and JOSEPH A. COOK*†¶
*University of Alaska Museum, 907 Yukon Drive, Fairbanks, Alaska 99775, USA, †Alaska Cooperative Fish and Wildlife Research Unit, University of Alaska, Fairbanks, Alaska 99775, USA, ‡Alaska Department of Fish and Game, PO Box 240020, Douglas, Alaska 99824, USA

Abstract

Phylogeographic patterns were used to assess intraspecific diversification of American martens (*Martes americana*). Within martens, two morphological groups (*americana* and *caurina*) have been recognized, though the level of distinction between them has been debated. We examined mitochondrial cytochrome *b* gene haplotypes from 680 martens to explore the colonization history of the Pacific Northwest and found two clades that correspond to the morphological groups. The widespread *americana* clade extends from interior Alaska south to Montana and eastward to Newfoundland and New England (i.e. northwestern, north-central and northeastern North America). The *caurina* clade occurs in western North America, minimally extending from Admiralty Island (southeastern Alaska) south to Oregon and Wyoming. Our data indicated two colonization events for the Pacific Northwest (one by members of each clade) and were consistent with the persistence of populations throughout past glacial periods in eastern and western refugia. Due to vegetational and geological history following the past deglaciation, we hypothesize that martens of the *caurina* clade spread along the North Pacific Coast, and into southeastern Alaska, earlier than martens of the *americana* clade. Mismatch distributions for the *americana* clade were indicative of populations that recently experienced demographic expansion, while mismatch distributions for the *caurina* clade suggested that populations were at equilibrium. These clades are reciprocally monophyletic and distinctive (interclade divergence ranged from 2.5 to 3.0% (uncorrected *p*), whereas, intraclade divergence was < 0.7%), and two regions of sympatry have been identified. Genetic signatures of past admixture in hybrid zones may have been extinguished during subsequent glacial periods when ranges contracted. This recurrent pattern of relatively restricted western, or Pacific coastal, lineages and more widespread eastern, or interior continental, lineages exists across broad taxonomic groups and suggests a shared biogeographical history.

Keywords: American martens, colonization, cytochrome *b*, *Martes*, Pacific Northwest, phylogeography

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Introduction

Our understanding of the dynamics of past movements and colonization of organisms traditionally has relied on the fossil record. Information on distributions gleaned from mammalian fossils is generally limited to taxonomic units at or above the level of species because sample sizes are seldom large enough to characterize geographical variation within species. However, molecular analyses applied within the framework of phylogeography (Avise 1994; Avise & Hamrick 1996) are providing further insight into the history of range expansions and contractions of many species (e.g. Wooding & Ward 1997; Bernatchez & Wilson 1998; Conroy & Cook 2000). DNA sequences have

Correspondence: Karen Stone. §Present address: Department of Biology, Southern Oregon University, 1250 Siskiyou Blvd., Ashland, OR 97520–5071 USA. Fax: (541) 552 6415; E-mail: stonek@sou.edu ¶Present address: Department of Biological Sciences, Idaho State University, Pocatello, Idaho 83209–8007, USA.

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been crucial in identifying lines of descent both at the intra- and interpopulation levels (e.g. Gilbert *et al*. 1990; Craighead *et al*. 1995), reconstructing colonization histories (Wooding & Ward 1997), and even exploring temporal variation in effective population size (Rogers & Harpending 1992; Rogers 1995; Schneider & Excoffier 1999). Molecular (and morphological) studies of extant species, in combination with palaeoecology, may provide opportunities to test hypotheses related to the effects of dramatic fluctuations during Pleistocene ice ages on genetic diversity in extant populations (Hewitt 1996).

Morphological analyses of recent specimens (Wright 1953; Anderson 1970; Giannico & Nagorsen 1989) and fossils (Graham & Graham 1994) have investigated the history and taxonomy of American martens, *Martes americana*. Although 14 subspecies of *M. americana* have been described (Hall 1981), these are traditionally placed in two morphologically distinct groups (*americana* and *caurina*). The *americana* group is distributed from Montana and Idaho northward to Alaska and eastward to the Atlantic Coast, while the *caurina* group is described from parts of the West Coast (California to British Columbia), Wyoming, Montana and Idaho (Fig. 1, inset map; Wright 1953; Hall 1981; Carr & Hicks 1997).

Although several studies (e.g. Merriam 1890; Anderson 1970; Hall 1981; Clark *et al*. 1987; Carr & Hicks 1997) have corroborated the separation of *M. americana* into these two groups, the level of distinctiveness between them has been debated. Originally described as distinctive species based on morphology (Merriam 1890), Wright (1953) reports intergradation between the groups and suggests they were conspecific. Molecular data from Carr & Hicks (1997) compares the divergence of these two groups to that of three Palearctic species of *Martes*. Because levels of divergence are as great between the *americana* and *caurina* clades as levels are among these Palearctic species, Carr & Hicks (1997) conclude that *americana* and *caurina* should be recognized as distinct species, *Martes americana* and *M. caurina*. We expand on this work by documenting the extent of geographical variation in the mitochondrial cytochrome *b* (cyt *b*) gene across populations of this species from the Pacific Northwest. We place a particular focus on southeastern Alaska, where secondary contact between these groups has been hypothesized (Giannico & Nagorsen 1989).

Southeastern Alaska is a heterogeneous landscape that encompasses the vast Alexander Archipelago (2000+ islands) and adjacent mainland with deep fjords, glaciers, temperate rainforest and alpine habitats. These features and a dynamic glacial history during the Pleistocene have contributed to a highly fragmented flora and fauna. Numerous nominal species and subspecies are endemic to the region (MacDonald & Cook 1996; Cook & MacDonald 2001). Phylogeographic investigations have revealed distinct evolutionary lineages of ermine (*Mustela erminea*; Fleming & Cook 2002), dusky shrew (*Sorex monticolus*; Demboski *et al*. 1999), brown bear (*Ursus arctos*; Talbot & Shields 1996), black bear (*U. americanus*; Stone & Cook 2000) and long-tailed voles (*Microtus longicaudus*; Conroy & Cook 2000). This high degree of endemism and diversity of lineages suggests a complex colonization history for deglaciated areas within the Pacific Northwest (Cook *et al*. 2001).

The existence of ice-free refugia during full glacial advances in the Pacific Northwest has been debated (e.g. Demboski *et al*. 1999). During the past glaciation, the Cordilleran Ice Sheet, in combination with portions of the Laurentide Ice Sheet, covered most of southeastern Alaska, Yukon Territory and British Columbia (Cowan 1989). The large number of coastal endemic taxa combined with molecular and palaeontological investigations of plants, insects, fish and mammals suggest, however, that portions of the Alexander Archipelago of southeastern Alaska and Haida Gwaii (Queen Charlotte islands) of British Columbia may have remained devoid of ice (Kavanaugh 1980; Warner *et al*. 1982; Heusser 1989; O'Reilly *et al*. 1993; Heaton *et al*. 1996; Byun *et al*. 1997). The high degree of endemism and repeated pattern of intraspecific lineage diversity across taxa of the North Pacific Coast may be the result of the persistence of refugial populations in these ice-free areas (palaeoendemic), or secondary contact of populations that have recently expanded into the region (neoendemic). Thus far, fossils of purported palaeoendemics that span the periods of glacial maxima have not been identified (Heusser 1989).

Some investigators suggest that other species have tracked the northern expansion of forests into previously glaciated regions of North America following the Pleistocene. We examined genetic differentiation of North American martens to elucidate the colonization history of this medium-sized carnivore and to compare this data set with a growing body of evidence for common phylogeographic history across forest-associated species in the Pacific Northwest.

Materials and methods

DNA extractions, polymerase chain reaction and sequencing of the cytochrome b *gene*

DNA was extracted from marten tissues (heart, kidney, liver, spleen, skeletal muscle, skin, or blood) archived in the Alaska Frozen Tissue Collection of the University of Alaska Museum (AFTC). Methods for extracting, amplifying and sequencing DNA, and aligning sequences were carried out according to Lessa & Cook (1998) unless otherwise noted. Amplifications were in 50 μL volumes containing 1.5 mM $MgCl_2$, 0.02 mM of each dNTP, 1.0 μM of each primer, 1.25 units of Perkin-Elmer Ampli*Taq* DNA

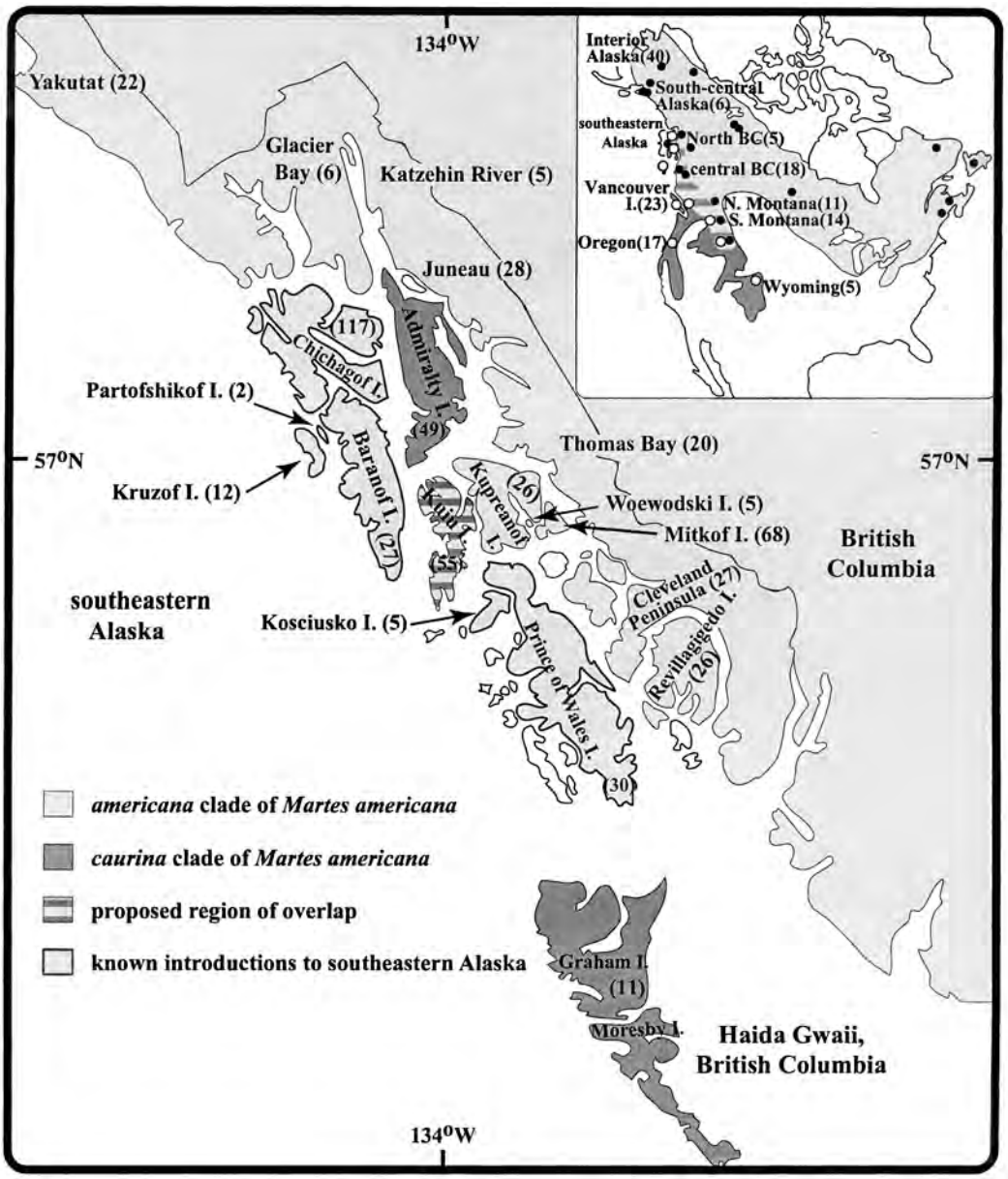

Fig. 1 Distribution of mitochondrial clades of American martens (*Martes americana*) in southeastern Alaska. Numbers in parentheses indicate sample sizes for locations analysed. Inset map shows the North American distribution of martens modified from Hall (1981) and plots sample localities from this study, Carr & Hicks (1997) and Hosoda *et al*. (1997). ● and ○ represent marten samples belonging to the *americana* and *caurina* clades, respectively.

polymerase, Perkin-Elmer 10× polymerase chain reaction (PCR) buffer and 1–100 ng whole genomic DNA. The mitochondrial (mt) marker, cyt *b*, was amplified using a Perkin-Elmer GeneAmp PCR System 2400 with the following PCR conditions: one cycle of 94 °C for 45 s, followed by 35 cycles of denaturation at 94 °C for 10 s, annealing at 45 °C for 15 s, and an extension at 72 °C for 45 s, followed by one cycle of 72 °C for 3 min. Negative controls were included in each PCR experiment. The following primer pairs amplified cyt *b*: MVZ4 and 5, 14 and 23, 16 and Marten37 (Table 1). Both forward and reverse strands were sequenced for each individual.

A total of 680 American martens were examined. Partial cyt *b* sequences [441 base pairs (bp) using primers MVZ16/Marten37; corresponding to sites 14498–14938 of *Mus musculus*; Bibb *et al*. 1981] were generated from 151 *Martes americana*, complete cyt *b* sequences (1140 bp; corresponding to sites 14139–15282 of *Mus musculus*; Bibb *et al*. 1981) were generated from 30 *M. americana*, and restriction fragment length polymorphism (RFLP) profiles were

Table 1 Sequences and associated references for primers used to amplify the mitochondrial cytochrome *b* gene

Primer	Sequence (5′ to 3′)	Reference
MVZ4	GCAGCCCCTCAGAATGATATTTGTCCTC	Smith & Patton (1993)
MVZ5	CGAAGCTTGATATGAAAAACCATCGTTG	Smith & Patton (1993)
MVZ14	GGTCTTCATCTYHGGYTTACAAGAC	Smith & Patton (1993)
MVZ23	TACTCTTCCTCCACGAAACJGGNTC	Smith & Patton (1993)
MVZ16	AAATAGGAARTATCAYTCTGGTTTRAT	Smith & Patton (1993)
Marten37	TATATATACCCCGAAACATGGA	Demboski *et al*. (1999)

determined for the remaining 499 individuals (Appendix I). All DNA sequences were deposited in GenBank under accession numbers: AF154964–74, AF268272–4, AF448237–8, AY121187–93, and AY121195–AY121352. Complete cyt *b* sequences were generated from one European pine marten (*M. martes*; GenBank AF448239) and one sable (*M. zibellina*; GenBank AF448244) and used as outgroups.

Population level analyses — 441-bp cyt b (n = *181)*

All population level analyses were carried out using the 441-bp sequence fragments of cyt *b* for 181 martens and the software package ARLEQUIN (version 2.0; Schneider *et al*. 2000). A minimum spanning tree (Kruskal 1956; Rohlf 1973) was constructed to display relationships among unique haplotypes. Analysis of molecular variance (AMOVA) estimated levels of population structure at different geographical scales (Excoffier *et al*. 1992). Nucleotide diversity ($\pi \pm$ SD) and haplotype diversity (*h*) were calculated for each population and clade, according to the formulae of Nei (1987). Mismatch distribution analyses (Schneider & Excoffier 1999) were performed for each clade to test for signatures of past population expansions. A sequence divergence estimate was calculated between individuals of the *americana* and *caurina* clades, according to Wilson *et al*. (1985). This method calculated a corrected average pairwise difference between individuals of the *americana* and *caurina* clades, $p_{AB(net)}$, by subtracting the average pairwise differences within populations (p_A and p_B) from the average pairwise difference between individuals of the two clades (p_{AB}); therefore, $p_{AB(net)} = p_{AB} - 0.5(p_A + p_B)$.

Phylogenetic analyses — 1140-bp cyt b (n = *30)*

Complete cyt *b* sequences were compared among 14 martens from southeastern Alaska (two mainland and 12 island samples), one from interior Alaska, seven from British Columbia (three mainland and four island samples), four from Montana, two from Oregon and two from Wyoming (Appendix I). Identical sequences for individuals from the same locality were removed resulting in a reduced data set of 22 sequences.

Relationships among sequences were examined using Phylogenetic Analysis Using Parsimony (PAUP*, version 4.0b3a; Swofford 1999). Phylogenetic trees were constructed using maximum parsimony (unweighted and transition/transversion weighting of 1/2, 1/5 and 1/10), maximum-likelihood, and neighbour-joining (Kimura two-parameter model of evolution; unweighted and transition/transversion weighting of 1/2, 1/5 and 1/10) methods. All searches produced trees with similar topologies therefore only the unweighted maximum parsimony analysis is shown. A strict consensus tree was generated from the four equally parsimonious trees that were constructed with a branch-and-bound search. Decay indices (Bremer 1988), reported as absolute number of steps, were computed using TreeRot (Sorenson 1996) for 100 bootstrap replicates, with maximum parsimony heuristic searches. Statistical support for the nodes of the strict consensus tree was assessed using the bootstrap (1000 replicates; Felsenstein 1985).

RFLP profiles (n = *499)*

We used RFLP analysis to document the geographical extent of the *americana* and *caurina* groups in the Pacific Northwest. A restriction enzyme (*Nla*III) that differentially digested PCR products from individuals of the americana and caurina clades was determined using DNA STRIDER 1.2 (written by C. Marck). A portion (approximately 830 bp) of the 3′ end of the cyt *b* gene and flanking region was amplified, using primers Marten37 and MVZ14, from 16 martens of known mt clades. A mixture of 9.0 μL PCR product, 1.0 μL New England Biolabs 10× buffer4, 0.10 μL bovine serum albumin (10 mg/mL) and 0.2 μL *Nla*III restriction enzyme (2 units) was placed in a 37 °C incubator for 2–3 h. DNA fragments were visualized on a 1.5% agarose gel stained with ethidium bromide. After RFLP banding patterns were established for the divergent clades, we screened an additional 499 martens to determine clade profiles across 25 localities (Appendix I). Positive controls were included in each RFLP digestion.

Results

Population level analyses — 441-bp cyt b (n = *181)*

A minimum spanning tree (Fig. 2a) displays relationships among the 16 haplotypes (Table 2). Of the 27 populations,

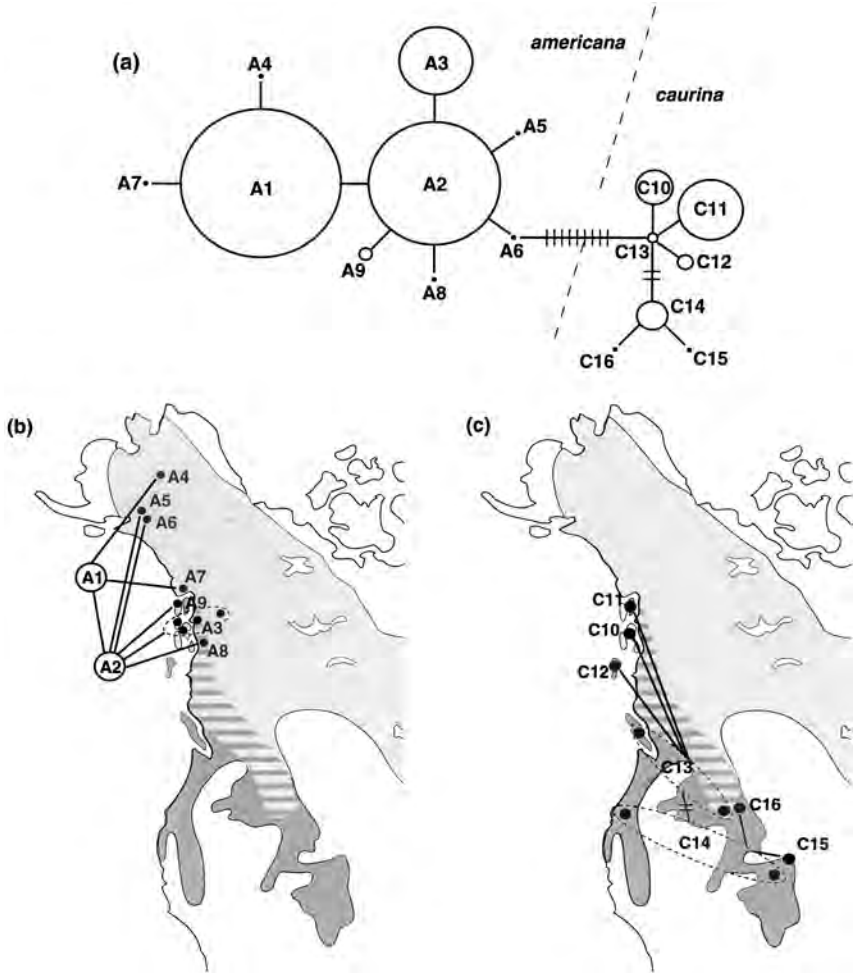

Fig. 2 (a) Minimum spanning tree showing relationships among American marten haplotypes. The circle size is proportional to the frequency of the haplotype (see Table 3 for specific values). Slash marks indicate the number of nucleotide substitutions found between haplotypes. No slash marks present indicates that a single substitution separates haplotypes. Haplotypes A1–A9 and C10–C16 are designated as belonging to the *americana* and *caurina* clades, respectively. These designations are based on the substantial division between the two clades of nine steps and analyses summarized in Fig. 3. (b) Map of western North America with the minimum spanning tree including haplotypes from the *americana* clade (see Table 3 for specific locations). Minimum spanning trees are overlaid upon the current distribution of marten (Hall 1981) with light and dark grey representing the *americana* and *caurina* clades, respectively. Haplotypes A1 and A2 were widespread throughout the mainland and many of the islands of the Alexander Archipelago. Circle size is not proportional to the frequency of the haplotypes. (c) Map of western North America with the minimum spanning tree including haplotypes from the *caurina* clade (see Table 3 for specific locations). Circle size is not proportional to the frequency of the haplotypes.

13 were characterized by a single haplotype, while 14 were represented by multiple haplotypes (Table 3). Haplotypes differed from common haplotypes by one or two nucleotide changes with the exception of a division of nine steps between the *americana* and *caurina* clades (Fig. 2a). The *americana* and *caurina* clades had nine and seven haplotypes, respectively (Fig. 2 and Table 3). AMOVA results confirmed the distinctive *americana–caurina* split with 88.9% of the variation accounted for between populations of the two clades. Only 7.9% of the variation was partitioned among populations within clades, and 3.2% of the variation was found within populations.

Two haplotypes from the *americana* clade (A1 and A2) were widespread throughout the mainland and many of the islands of the Alexander Archipelago (Table 3). A third haplotype from the *americana* clade (A3) was found in northern British Columbia, and the mainland and four islands of southeastern Alaska. All other haplotypes from the *americana* clade were unique to a single population and differed from either A1 or A2 by one nucleotide (Fig. 2). Haplotypes from the *caurina* clade were less widespread and more restricted to individual populations (Table 3). Of the seven populations possessing *caurina* haplotypes, five had unique haplotypes (Table 3).

Of the 27 populations, 20 are represented by only *americana* haplotypes, five populations are characterized by only *caurina* haplotypes, and two populations are represented by both *americana* and *caurina* haplotypes. Not surprisingly, nucleotide diversity (π) is highest for these two latter populations (Montana and Kuiu Island, southeastern Alaska; Table 3). Several populations had low or no nucleotide diversity (Table 3). Overall haplotype diversity (h) was 0.83 but ranged from 0.00 to 1.00 for individual populations (Table 3).

The mismatch distribution of observed number of differences between pairs of haplotypes was unimodal for the *americana* clade, possibly suggesting that members of this clade have recently passed through a demographic expansion (Rogers & Harpending 1992). However, the mismatch distribution for the *caurina* clade was bimodal — an indication of demographic equilibrium. At the 95% confidence level, ranges for ancestral (θ_0) and current (θ_1) theta values did not overlap for the *americana* clade (θ_0 = 0.000–1.019; θ_1 = 6.357–4830.938). Similarly, but less

Table 2 Condensed dot matrix displaying variable sites of the mtDNA cytochrome *b* gene in 181 American martens (*Martes americana*)

	Nucleotide position																				
Haplotype	438	445	447	468	477	480	528	565	569	576	577	585	603	618	713	722	732	770	777	783	792
A1	T	T	G	C	T	T	G	A	C	A	G	T	C	T	T	T	A	C	C	A	G
A2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	T	·	·	·
A3	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	T	T	·	·
A4	·	·	·	·	·	·	·	·	·	·	A	·	·	·	·	·	·	·	·	·	·
A5	C	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	T	·	·	·
A6	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	T	·	·	A
A7	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	C	·	·	·	·	·
A8	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	C	·	T	·	·	·
A9	·	·	·	·	C	·	·	·	·	·	·	·	·	·	·	·	·	T	·	·	·
C10	·	C	A	·	C	C	·	·	T	G	·	A	T	·	C	·	·	T	·	G	A
C11	·	C	A	T	·	C	·	·	T	G	·	A	T	·	C	·	·	T	·	G	A
C12	·	C	A	·	·	C	·	·	T	G	·	A	T	·	C	·	·	·	·	G	A
C13	·	C	A	·	·	C	·	·	T	G	·	A	T	·	C	·	·	T	·	G	A
C14	·	C	A	·	·	C	A	G	T	G	·	A	T	·	C	·	·	T	·	G	A
C15	·	C	A	·	·	C	A	G	T	G	·	A	T	C	C	·	·	T	·	G	A
C16	·	C	A	·	·	C	A	G	T	G	·	A	T	·	C	·	G	T	·	G	A

Haplotype names are shown on the left, and nucleotide positions are displayed at the top with position 1 representing the first nucleotide of the gene. Dots within the matrix represent identical nucleotides to the reference sequence. Haplotypes A1–A9 and C10–C16 are designated as belong to the *americana* and *caurina* clades, respectively. These designations are based on analyses summarized in Figs 2 and 3.

disparately, θ_0 and θ_1 estimates for the *caurina* clade did not overlap (θ_0 = 0.000–1.679; θ_1 = 2.755–4669.431). These results indicated that populations within the clades have expanded in the recent past, particularly within the *americana* clade. However, these analyses may be confounded by the limited levels of intraclade variation (maximum of four nucleotide differences between the most distant haplotypes within each clade).

The corrected average pairwise difference between individuals of the *americana* and *caurina* clades was 10.4 nucleotides (or 2.4%). If we assume a divergence rate of 2.5% per million years per pair of clades, as in Carr & Hicks (1997) and Carr & Hughes (1993), then individuals of the *americana* and *caurina* clades diverged approximately 1 million years ago. However, this estimate is imprecise due to the method of calibration and other sources of error (see Stone & Cook, 2002).

Phylogenetic analyses — 1140-bp cyt b (n = *30)*

Base composition (A = 28.0%, C = 31.0%, *G* = 14.5%, T = 26.5%) for cyt *b* was consistent with that of other mammals (e.g. Irwin *et al*. 1991; Talbot & Shields 1996; Stone & Cook 2000). A linear relationship (R^2 = 0.945) between third-position transitions and uncorrected *p* distances calculated for the genus *Martes* (data not shown) indicated that saturation has not been attained.

Four equally parsimonious trees (112 steps with 65 informative characters) displayed two reciprocally monophyletic clades corresponding to the *americana* and *caurina* morphological groups. Two subclades within the *caurina* clade (Fig. 3) were also apparent. Divergence between clades ranged from 2.5 to 3.0% (uncorrected *p*), whereas, intraclade divergence was < 0.5% and < 0.7% for the *americana* and *caurina* clades, respectively.

For the complete cyt *b* gene, 27 nucleotide sites (26 transitions and one transversion) differed between the *americana* and *caurina* clades (five first-position, two second-position and 20 third-position transitions). The single transversion (third-position) did not result in an amino acid change; however, three of the transitions (one first-position and both second-position) coded for different amino acids. All three amino acid differences corresponded to hypervariable residues previously identified in a cyt *b* model (Irwin *et al*. 1991).

Four nucleotide sites differed between the two subclades within *caurina* (one first- and three third-position transitions). Three third-position transitions were synonymous, whereas, the first-position transition resulted in an amino acid change. This nonsynonymous change occurred in the trans-membranous region of the protein. These results were expected for PCR amplifications of genuine mt cyt *b* (as opposed to a nuclear pseudogene).

RFLP profiles (n = *499)*

Restriction enzyme digestion of the amplified fragment of cyt *b* from martens of the *caurina* clade resulted in three smaller fragments; whereas, fragments from martens of the *americana* clade remained uncut and, therefore, maintained

Table 3 Population locations, number of haplotypes (H#), nucleotide diversity ($\pi \pm$ SD), haplotype diversity (h), frequency of haplotypes, and sample sizes (n) for mtDNA cytochrome *b* variation in American martens (*Martes americana*)

				Frequency of haplotype																
				americana haplotypes									*caurina* haplotypes							
Population	H#	$\pi \pm$ SD	h	A1	A2	A3	A4	A5	A6	A7	A8	A9	C10	C11	C12	C13	C14	C15	C16	n
Interior Alaska	3	0.0013 ± 0.0013	0.51	7	2	·	1	·	·	·	·	·	·	·	·	·	·	·	·	10
South-central Alaska	3	0.0018 ± 0.0018	0.70	·	3	·	·	1	1	·	·	·	·	·	·	·	·	·	·	5
Northern British Columbia	3	0.0023 ± 0.0021	0.70	3	1	1	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Central British Columbia	2	0.0014 ± 0.0014	0.60	3	3	·	·	·	·	·	·	·	·	·	·	·	·	·	·	6
Montana	4	0.0197 ± 0.0138	1.00	1	1	·	·	·	·	·	·	·	·	·	·	1	·	·	1	4
Yakutat, SE AK	1	0.0000 ± 0.0000	0.00	·	5	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Glacier Bay, SE AK	2	0.0011 ± 0.0014	0.50	3	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·	4
KatzehinRiver, SE AK	1	0.0000 ± 0.0000	0.00	·	5	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Juneau, SE AK	2	0.0014 ± 0.0015	0.60	3	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Thomas Bay, SE AK	3	0.0023 ± 0.0021	0.70	1	1	3	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Cleveland Peninsula, SE AK	3	0.0023 ± 0.0021	0.70	3	1	·	·	·	·	·	1	·	·	·	·	·	·	·	·	5
Chichagof I., SE AK	3	0.0013 ± 0.0012	0.51	1	10	·	·	·	·	·	·	4	·	·	·	·	·	·	·	15
Baranof I., SE AK	1	0.0000 ± 0.0000	0.00	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	10
Kruzof I., SE AK	1	0.0000 ± 0.0000	0.00	·	·	5	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Partofshikof I., SE AK	1	0.0000 ± 0.0000	0.00	·	·	2	·	·	·	·	·	·	·	·	·	·	·	·	·	2
Kupreanof I., SE AK	1	0.0000 ± 0.0000	0.00	·	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2
Mitkof I., SE AK	2	0.0014 ± 0.0015	0.60	3	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Woewodski I., SE AK	1	0.0000 ± 0.0000	1.00	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1
Kuiu I., SE AK	4	0.0144 ± 0.0079	0.67	5	3	3	·	·	·	·	·	·	12	·	·	·	·	·	·	23
Revillagigedo I., SE AK	1	0.0000 ± 0.0000	0.00	5	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Prince of Wales I., SE AK	2	0.0008 ± 0.0010	0.35	8	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	10
Kosciusko I., SE AK	1	0.0000 ± 0.0000	0.00	5	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5
Admiralty I., SE AK	1	0.0000 ± 0.0000	0.00	·	·	·	·	·	·	·	·	·	·	21	·	·	·	·	·	21
Graham I., B.C.	1	0.0000 ± 0.0000	0.00	·	·	·	·	·	·	·	·	·	·	·	5	·	·	·	·	5
Vancouver I., B.C.	1	0.0000 ± 0.0000	0.00	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	2
Oregon	1	0.0000 ± 0.0000	0.00	·	·	·	·	·	·	·	·	·	·	·	·	·	6	·	·	6
Wyoming	2	0.0009 ± 0.0012	0.40	·	·	·	·	·	·	·	·	·	·	·	·	·	4	1	·	5
americana clade	10	0.0021 ± 0.0016	0.69	52	43	24	1	1	1	1	1	4	0	0	0	0	0	0	0	128
caurina clade	6	0.0041 ± 0.0027	0.76	0	0	0	0	0	0	0	0	0	12	21	5	3	10	1	1	53
Total	16	0.0125 ± 0.0067	0.83	52	43	24	1	1	1	1	1	4	12	21	5	3	10	1	1	181

Haplotypes A1–A9 and C10–C16 are designated as belong to the *americana* and *caurina* clades, respectively. These designations are based on analyses summarized in Figs 2 and 3.

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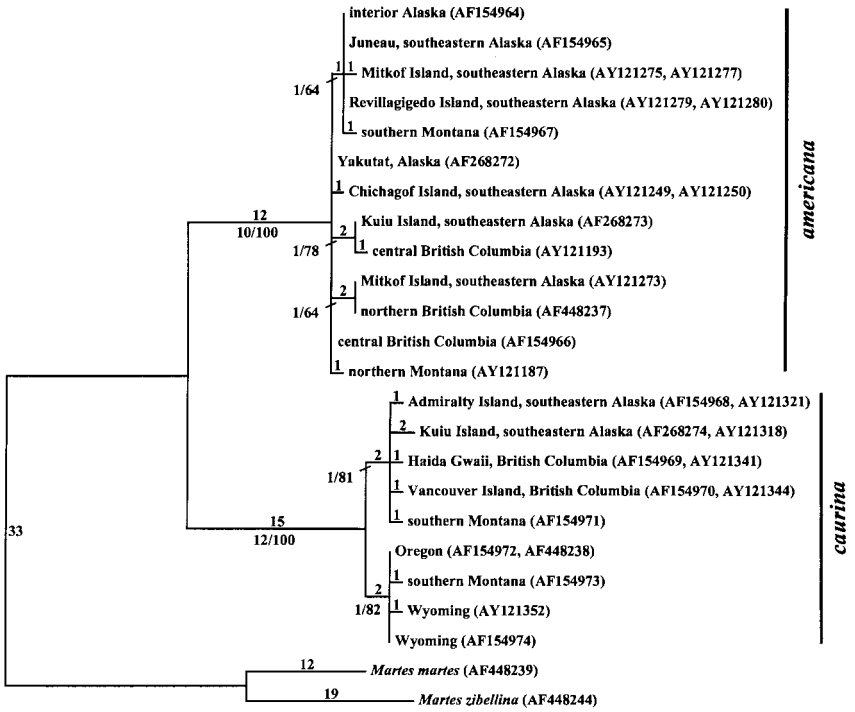

Fig. 3 Strict consensus tree of four equally parsimonious trees (length = 112 steps; CI = 0.9107; RI = 0.9669) generated from complete cytochrome *b* gene sequences of American martens (*Martes americana*) with a branch-and-bound search. Branch lengths are shown above branches, and Bremer decay indices/bootstrap values are below branches. GenBank accession numbers are in parentheses after taxon names.

only a single fragment. RFLP analysis identified 413 *americana* and 86 *caurina* haplotypes (Appendix I). These larger sample sizes allowed us to map more confidently the spatial extent of these two clades (Fig. 1). The widespread *americana* extends from interior Alaska south to Montana and eastward to Newfoundland and New England. The eastern distribution of *americana* is based on the work of Carr & Hicks (1997) and Hosoda *et al*. (1997). The *caurina* clade minimally extends from Admiralty Island, southeastern Alaska south to Oregon and Wyoming (Fig. 1, inset map). Two regions of sympatry were identified, Montana and Kuiu Island, southeastern Alaska. Northern Montana samples ($n = 11$) consisted of strictly *americana* haplotypes; whereas, southern Montana samples were comprised of two *americana* haplotypes and 12 *caurina* haplotypes. Samples from Kuiu Island consisted of 33 *americana* and 22 *caurina* haplotypes.

Discussion

Glacial refugia and intraspecific differentiation

Mengel (1964) proposed that vicariant events, due to repeated glaciations during the Pleistocene, initiated speciation in North American warblers (Parulidae). This idea has been extended to several forest-associated species, including northern flying squirrels (*Glaucomys sabrinus*), tree squirrels (*Tamiasciurus douglasii*, *T. hudsonicus*), southern red-backed voles (*Clethrionomys gapperi*), black bears (*Ursus americanus*), and chickadees [*Poecile* (*Parus*) *hudsonica*, *P. rufescens*] (Wooding & Ward 1997; Arbogast & Kenagy 2001; Cook *et al*. 2001). A recurrent pattern of relatively restricted western, or Pacific coastal, lineages and more widespread eastern, or interior continental lineages, exists across broad taxonomic groups and suggests a shared biogeographical history.

American martens also show two distinct clades in western North America. Bootstrap support and decay indices highly supported the recognition of distinct clades (Fig. 3), and a total of 88.9% of the molecular variation is partitioned between populations of the populations of the americana and caurina clades, *americana* and *caurina*. These results corroborate and expand the findings of Carr & Hicks (1997). The *americana* and *caurina* clades differed by 2.5–3.0% (uncorrected *p*) overall sequence variation with intraclade variation < 0.7%. This level of variation reflects approximately 1 million years since divergence. We hypothesize that this divergence was accumulated through allopatry spanning several glacial cycles, as has been proposed for several taxa (Klicka & Zink 1997; Avise & Walker 1998; Avise *et al*. 1998).

Wooding & Ward (1997) propose that the existence of eastern and western forest refugia in North America during past glacial advances would account for two highly divergent clades of black bears. During much of the last 120 000 years, they contend these segregated forests formed a barrier to dispersal for other forest-associated species. While ice sheets were receding, eastern forests apparently expanded more rapidly than western forests (Williams *et al*. 1993), and therefore, populations representing the eastern clade of black bears expanded more extensively

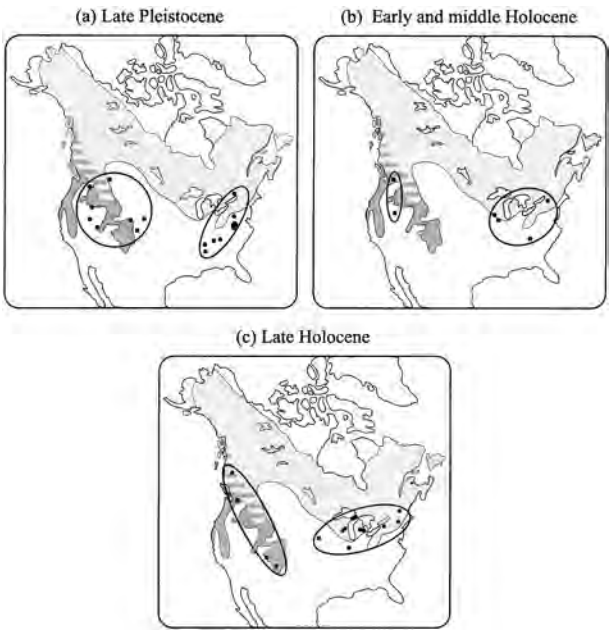

Fig. 4 Figure modified from Graham & Graham (1994) of fossil records of American martens, *Martes americana*, from (a) late Pleistocene, (b) early/middle Holocene, and (c) late Holocene. Fossil records are overlaid upon the current distribution of marten (Hall 1981) with light and dark grey representing the *americana* and *caurina* clades, respectively. Lines encircle fossil records hypothesized to belong to the *americana* clade in eastern and the *caurina* clade in western North America.

across northern North America than populations representing the western clade.

American martens show a pattern of sequence divergence and geographical diversification similar to that of black bears (Wooding & Ward 1997; Stone & Cook 2000), with relatively large interclade and small intraclade differences. Two morphologically defined groups of martens correspond to the reciprocally monophyletic clades identified with genetic analyses. Similarly, the distribution of late Pleistocene–late Holocene fossil records of martens also supports the hypothesis of separate forest refugia since the last (Wisconsin) glaciation (Fig. 4). Furthermore, the phylogeographic pattern in martens is consistent with Hoffmann's idea that taxa from large refugia in southeastern North America expanded into a larger area after the past glaciation than did taxa from smaller western refugia (Hoffmann 1985).

Broad correspondence in sequence divergence and geographical distribution of eastern and western clades in martens, black bears and other taxa (e.g. *Glaucomys sabrinus*, Arbogast 1998; *Parus hudsonicus* and *P. rufescens*, Gill *et al*. 1993; *Dendroica coronata* and *D. auduboni*, Bermingham *et al*. 1992) implicates similar vicariant events. Although we cannot effectively address the rate or timing of movement of these taxa at this time, these data suggest comparable colonization routes across diverse taxonomic units. Several taxa tend to overlap spatially (Clementsian manner) as opposed to exhibiting independent colonizations (Gleasonian), a pattern also found for some North American rodents (Riddle 1996). These concordant phylogeographic patterns seem to falsify the suggestion of Graham *et al*. (1996; p. 1605) that 'species that make up mammal communities in the contiguous United States have responded to late Quaternary environmental fluctuations in a Gleasonian manner.'

Relatively high sequence divergence indicated that vicariance between the two clades extended deeper than the last glaciation as suggested for other carnivores (e.g. 5.0% control region variation = 3.3% cyt *b* variation for black bears = 1.8 ± 0.8 million years since divergence, Wooding & Ward 1997; Stone & Cook 2000) and many other taxa (Klicka & Zink 1997; Avise *et al*. 1998). Estimates of divergence may be heavily influenced, however, by a variety of factors such as levels of ancestral polymorphisms (Edwards & Beerli 2000). Populations of the divergent clades may have come into secondary contact multiple times over the past million years during interglacial periods (e.g. Leonard *et al*. 2000), but we detected no genetic signature of past contact (e.g. individuals with divergent *americana* mitochondrial DNA located in western United States). Limited genetic admixture, occurring during the repeated northward expansions of these populations during interglacial periods, may have been eliminated by subsequent population retractions during glacial advances (Hewitt 1996).

Within the *americana* clade, little to no geographical structure was present among populations (Table 3, Figs 2 and 3). Three haplotypes (A1–3) were relatively widespread and occurred at high frequencies; whereas, the remaining six *americana* haplotypes (A4–9) were each found only in one population and occurred in low frequencies (Table 3, Fig. 2b). The unimodal mismatch distribution for this clade was indicative of a population that experienced demographic expansion (Rogers & Harpending 1992). Ancestral (θ_0) and current (θ_1) theta values were also consistent with expansion in the recent past.

Within *caurina*, several haplotypes were confined to single populations (Table 3, Figs 2c and 3). Within this clade (Fig. 3), subclade divergence apparently was initiated by the mid-Pleistocene during separation into distinctive refugial populations in western North America. The slight variation within each subclade (Fig. 3) may reflect divergence since the last glaciation. Our data were consistent with a glacial refugium along the North Pacific Coast; however, if hypotheses regarding the locations of refugia are to be critically tested with genetic data, more extensive sampling from throughout the range of the *caurina* clade should be investigated with multiple independent loci.

The mismatch distribution for the *caurina* clade was bimodal — more indicative of a population at demographic equilibrium. However, ancestral (θ_0) and current (θ_1) theta values indicated that this population may have expanded in the recent past. Again, we caution that the mismatch analysis is highly confounded by the limited levels of intraclade variation found in the cyt *b* gene. Additional molecular data from more rapidly evolving portions of DNA (e.g. mitochondrial DNA control region) are needed to test these findings.

Colonization history of a forest-associated mammal and contact zones

The close relationship of martens with late-successional forests has been compared to that of spotted owls (*Strix occidentalis*) and red-cockaded woodpeckers (*Picoides borealis*) (Thomas *et al*. 1988; Thompson 1991). Dependence of martens on overhead tree cover and an associated complex ground structure (Buskirk & Powell 1994) is consistent with an expected correspondence between its range expansion and that of forests. Lodgepole pine, *Pinus contorta*, was established as early as 10 500 years before present (BP) along the southeastern Alaskan coast, but establishment on the inland (eastern) side of the Coast Mountain Range did not occur until about 2300 BP (Peteet 1991). Mathewes (1989) and Fedje & Josenhans (2000) suggest the arrival of coniferous trees as early as 12 200 BP to the coastal region just south of southeastern Alaska (Haida Gwaii of British Columbia). The coastal corridor may have been broader due to a lower sea level at that time (Barrie *et al*. 1993; Fedje and Josenhans 2000). Because we expected a general correlation between range expansion of vegetation and associated animals (Hewitt 1996), the ice-free, coastal corridor may have served as a route for forest-associated species, such as martens, to colonize the coast from a southerly refugial population (MacDonald & Cook 1996).

Due to this forest association and the geographical proximity of purported western forest refugia to the North Pacific Coast, we hypothesize that the individuals belonging to the *caurina* (coastal) clade colonized along the North Pacific Coast (including southeastern Alaska) earlier than individuals from the more widespread *americana* clade (see Fig. 4C). We suspect that individuals representing the *americana* clade colonized the coastal region during the Holocene when recession of the Cordilleran Ice Sheet would have allowed western movement through low elevation passes and rivers that transect the Coast Range.

Individuals of the *caurina* clade extend northward to Admiralty Island, and are not found in interior Alaska. This pattern is repeated among several forest-associated taxa (MacDonald & Cook 1996). The Pacific coastal, or western, clade is often restricted to the coast and does not extend farther north than southeastern Alaska but the interior continental, or eastern, clade projects across northern North America into interior Alaska (see Cook *et al*. 2001 and Arbogast & Kenagy 2001 for examples). This common pattern among several taxa suggests that similar forces have shaped current distributions, such as barriers to dispersal north of southeastern Alaska. Alternatively, the pattern may be due to competition among individuals of the two clades, whereby, individuals from one clade are able to outcompete individuals from another clade under certain ecological circumstances. These are suppositions and should be investigated with future work.

Admiralty, Kuiu and Graham (Haida Gwaii) islands supported only *caurina* haplotypes (Table 3 and Fig. 3) suggesting that these populations have been isolated. Although haplotypes were unique, differentiation was minimal (one or two mutations) suggesting differentiation within the Holocene and supporting Giannico & Nagorsen's (1989) idea that the distinct phenotype of martens from Haida Gwaii (Queen Charlotte islands) evolved very recently. Martens carrying *americana* haplotypes apparently followed the westward progression of the eastern refugial forest. This colonization could have resulted in the shared occurrence of *americana* haplotypes on the mainland and near-shore islands (Table 3 and Figs 2b and 3).

The limited distribution of the *caurina* clade to several islands may be partially the result of genetic swamping of this clade elsewhere by the *americana* clade following its later arrival to the coast. When gene flow is relatively high between two taxa, interbreeding may cause outbreeding depression or even extinction via hybridization or genetic assimilation (Ellstrand 1992). Extensive sampling in southeastern Alaska revealed only one region of contact, Kuiu Island, and we suspect this area was colonized recently by individuals of the *americana* clade as a result of island hopping across Mitkof and Kupreanof islands (peninsular effect) due to shallow water channels (Fig. 1). Other typically mainland species show a similar distribution (MacDonald & Cook 1996). Possible introgression and/or genetic swamping of *caurina* by *americana* individuals should be investigated using a combination of mitochondrial and nuclear markers, and possibly an experimental breeding programme. Individuals of the *caurina* clade may persist on Admiralty, Graham (Haida Gwaii) and Vancouver because these islands are sufficiently isolated from individuals of the *americana* clade. Only one other region of contact, southern Montana, was revealed in this study, though that contact zone presumably extends from Montana northwest through British Columbia (also see Wright 1953).

Human introductions of martens

In the 1930s, introductions of martens were made by the Alaska Game Commission to Baranof and Prince of Wales

islands followed by the introduction of martens to Chichagof Island during 1949–52. These transplantations were made without knowledge of the underlying morphological and genetic variation that exists across the region (Elkins & Nelson 1954; Burris & McKnight 1973; MacDonald & Cook 1996). Marten populations were thought to not exist on these islands before introductions, but this presumption was questioned due to the rapid increase in numbers on Prince of Wales Island following transplantation (Elkins & Nelson 1954). Extensive sampling of these introduced populations (e.g. Chichagof Island, $n = 117$) suggested that the individuals representing the *americana* clade had been the sole source of these introductions. Giannico & Nagorsen's (1989) morphological assessment of samples from Baranof and Chichagof islands indicated that these populations belong to the *americana* clade. Our data corroborated their findings. However, contrary to their conclusion that *americana* was found exclusively throughout the region, our extensive sampling indicated that some individuals (martens from Admiralty Island and some martens from Kuiu Island) also belong to the *caurina* clade.

Our analyses provided no indication that martens existed on Chichagof, Baranof, or Prince of Wales islands prior to introductions, but this conclusion may be premature because it was derived from a mitochondrial gene that may not effectively detect genetic swamping. Additional nuclear markers should be used to test this hypothesis (see for example, Paetkau *et al*. 1998). If the islands were naturally colonized first by individuals of the *caurina* clade, perhaps when sea levels were lower at the end of the Pleistocene, then the persistent populations of *caurina* on Admiralty and Kuiu islands may be remnants of a previously widespread clade across the archipelago. Although the disjunct distribution of the *caurina* clade (i.e. *caurina* on Admiralty and Kuiu islands) may conversely appear to be the result of introductions, we doubt this is the case because both populations have fixed, unique haplotypes unlike those from documented population introductions on Chichagof and Baranof islands.

The genetic substructure, displayed by marten populations along the North Pacific Coast, is consistent with independent colonizations of the region by representatives of the two divergent clades. These data further exemplify the need to develop a historical framework for the biota of a region through extensive sampling, if we are to hope to effectively understand and manage the complexities associated with environmental change (Wilson 2000).

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This work comprises a portion of the PhD dissertation of Karen Stone on molecular evolution of martens (genus *Martes*). The study was conducted at the University of Alaska Fairbanks in the laboratory of Joseph Cook, whose interests lie in evolution and conservation of mammals. Karen Stone is currently an assistant professor of biology at Southern Oregon University and is conducting mammalian research. Joseph Cook is now a professor of biology at Idaho State University. Rodney W. Flynn is a research wildlife biologist with the Alaska Department of Fish and Game and project leader for marten ecological studies in southeastern Alaska.

Appendix I

Collection locations, clade profiles, molecular methods used and voucher number for *Martes americana* specimens

Locality*	Clade	Method(s)†	Alaska Frozen Tissue Collection number
Chichagof Island, SE AK	*americana*	full cyt *b*	10755–6
Chichagof Island, SE AK	*americana*	441-bp cyt *b*	10758–60, 14524–6, 14540, 14550, 14553, 19996–7, 30673–4
Chichagof Island, SE AK	*americana*	R	10761–2, 14495–512, 14514–42, 14544–75, 15999, 16000, 16067–70, 19889–97, 19964–74, 19996–8
Baranof Island, SE AK	*americana*	441-bp cyt *b*	19902–3, 19907, 19916, 19918, 19934, 19975–8
Baranof Island, SE AK	*americana*	R	19908–11, 19917, 19919–22, 19926, 19929–33, 19935–6
Kruzof Island, SE AK	*americana*	441-bp cyt *b*	19904–6, 19913, 19923
Kruzof Island, SE AK	*americana*	R	19914–5, 19924–5, 19927, 24019–20
Partofshikof Island, SE AK	*americana*	441-bp cyt *b*	19912, 19928
Kupreanof Island, SE AK	*americana*	441-bp cyt *b*	10823, 16027
Kupreanof Island, SE AK	*americana*	R	20074, 20081, 24440, 24442–4, 24448, 24498–9, 24527–30, 24533, 24539–43, 24550–4
Mitkof Island, SE AK	*americana*	full cyt *b*	10829–30, 10832
Mitkof Island, SE AK	*americana*	441-bp cyt *b*	10831, 14475
Mitkof Island, SE AK	*americana*	R	14476–90, 14492–4, 16028–32, 16034–53, 16057, 19937–40, 19947–61
Woewodski Island, SE AK	*americana*	441-bp cyt *b*	10822
Woewodski Island, SE AK	*americana*	R	20075–6, 24416–7
Kuiu Island, SE AK	*americana*	full cyt *b*	17541
Kuiu Island, SE AK	*americana*	441-bp cyt *b*	17534, 17536–9, 17543, 17546, 17549, 17551, 19888
Kuiu Island, SE AK	*americana*	R	24471, 24473–4, 25302, 25304–6, 25310–15, 25318, 25324–6, 25328–9, 25332–4
Prince of Wales Island, SE AK	*americana*	441-bp cyt *b*	10665–8, 10670, 10673, 10678–9, 10684–5
Prince of Wales Island, SE AK	*americana*	R	14629–32, 15903, 15909–12, 15917–8, 15924–6, 15940, 15942, 15948, 15977, 15980, 15997
Kosciusko Island, SE AK	*americana*	441-bp cyt *b*	15904–8
Revillagigedo Island, SE AK	*americana*	full cyt *b*	10707–8
Revillagigedo Island, SE AK	*americana*	441-bp cyt *b*	10709, 10711–2
Revillagigedo Island, SE AK	*americana*	R	10690–4, 10710, 10713–5, 10721–2, 10724, 10726–7, 14634–5, 14639–43
Yakutat, SE AK	*americana*	full cyt *b*	10769
Yakutat, SE AK	*americana*	441-b cyt *b*	10770–3
Yakutat, SE AK	*americana*	R	10774–89, 24454
Glacier Bay, SE AK	*americana*	441-bp cyt *b*	10848–51, 14628
Glacier Bay, SE AK	*americana*	R	19990
KatzehinRiver, SE AK	*americana*	441-bp cyt *b*	14591–5
KatzehinRiver, SE AK	*americana*	R	14592
Juneau, SE AK	*americana*	full cyt *b*	14952
Juneau, SE AK	*americana*	441-bp cyt *b*	14954, 14956–7
Juneau, SE AK	*americana*	R	10763–6, 10833, 10852–3, 14951, 14953, 14955, 14958–65, 19962–3, 20063, 20065, 20068, 20070
Thomas Bay, SE AK	*americana*	441-bp cyt *b*	19941–5
Thomas Bay, SE AK	*americana*	R	19946, 20071–3, 20077–80, 24500–6
Cleveland Peninsula, SE AK	*americana*	441-bp cyt *b*	10695–9
Cleveland Peninsula, SE AK	*americana*	R	10700–6, 10717, 14653–7, 14659–64, 14666–7, 14669
Interior Alaska	*americana*	full cyt *b*	53
Interior Alaska	*americana*	441-bp cyt *b*	50–2, 54, 144, 146, 148, 30671–2
Interior Alaska	*americana*	R	24601–15, 24627, 24629, 24631–2, 24636–46
South-central Alaska	*americana*	441-bp cyt *b*	14111–2, 14114–6
South-central Alaska	*americana*	R	13559
northern BC	*americana*	full cyt *b*	16004
northern BC	*americana*	441-bp cyt *b*	16005–8
northern BC	*americana*	R	16007
central BC	*americana*	full cyt *b*	16010, 16020
central BC	*americana*	441-bp cyt *b*	16009, 16014–5, 16019
central BC	*americana*	R	16011–3, 16016–8, 16021–3, 16026, 16033, 20612

Appendix I *Continued*

Locality*	Clade	Method(s)†	Alaska Frozen Tissue Collection number
northern Montana	*americana*	full cyt *b*	23185
northern Montana	*americana*	R	23180–2, 23185–92
southern Montana	*americana*	full cyt *b*	23183
southern Montana	*americana*	R	23183–4
Admiralty Island, SE AK	*caurina*	full cyt *b*	14470, 14972
Admiralty Island, SE AK	*caurina*	441-bp cyt *b*	14973, 16063, 16073–4, 16076–81, 19898–901, 19979–82, 19993
Admiralty Island, SE AK	*caurina*	R	19983–8, 19994–5, 20069, 24424–37, 24439, 24464–7
Kuiu Island, SE AK	*caurina*	full cyt *b*	17533, 17552
Kuiu Island, SE AK	*caurina*	441-bp cyt *b*	17535, 17540, 17542, 17544–5, 17547–8, 17550, 17553, 19887
Kuiu Island, SE AK	*caurina*	R	24472, 25301, 25303, 25307, 25309, 25316, 25319, 25321, 25327, 25330
Graham Island, Haida Gwaii, BC	*caurina*	full cyt *b*	20601, 20604
Graham Island, Haida Gwaii, BC	*caurina*	441-bp cyt *b*	20603, 20605–6
Graham Island, Haida Gwaii, BC	*caurina*	R	20602, 20607–11
Vancouver Island, BC	*caurina*	full cyt *b*	24477–8
Vancouver Island, BC	*caurina*	R	24475–8, 24479–97
southern Montana	*caurina*	full cyt *b*	23169, 23171
southern Montana	*caurina*	R	23168–79
Oregon	*caurina*	full cyt *b*	15936–7
Oregon	*caurina*	441-bp cyt *b*	15931, 15935, 15938–9
Oregon	*caurina*	R	15941, 19543, 15945–7, 15950–5
Wyoming	*caurina*	full cyt *b*	20613–4
Wyoming	*caurina*	441-bp cyt *b*	20615–7

*SE AK = southeastern Alaska; BC = British Columbia.
†Automated sequencing of the complete mitochondrial cytochrome *b* gene (full cyt *b*), partial cytochrome *b* gene (441-bp cyt *b*) or screening with a restriction enzyme digestion (R).

SECTION 10

MAN-CAUSED PROBLEMS AND THEIR CONTROL

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CHANNEL INSTABILITY IN A STRIP-MINED BASIN

by Andrew J. Miller, Associate Professor, University of Maryland Baltimore County, Baltimore, Maryland, and Hydrologist, U.S. Geological Survey, Reston, Virginia

ABSTRACT

Smoky Creek, a tributary (drainage area = 85 km^2) of the New River in the Cumberland Plateau of eastern Tennessee, drains one of the most heavily strip-mined basins of its size in the eastern U.S. Strip mining has caused radical increases in sediment yield, including a large increase in the supply of coarse sediment to the channel system. Patterns of geomorphic adjustment to these changes have been variable along its length; channel instability occurs primarily at major deposition zones below tributary confluences or at channel bends, and these sites of aggradation are marked by slope breaks on the longitudinal profile. A 50-year record of change at one such location documents the downstream propagation of a wave of instability. Most of the bar growth and bank erosion occurred in conjunction with increased strip-mine activity after 1968, with a maximum bank retreat of 50 m between 1971 and 1983. Other deposition zones are occupied by vegetated bar/island complexes that have remained in the same position since 1938. Some of these may have formed during a previous phase of channel instability caused by logging in the Smoky Creek basin between 1912 and 1929.

INTRODUCTION

Surface mining has long been recognized as a significant form of landscape disturbance with potentially serious downstream impacts, particularly in mountain environments. Inundation of fluvial systems by coarse sediment derived from mine spoils leads to aggradation, gravel-bar formation, channel widening, local steepening of channel gradients and onset of braiding, as well as accumulation of coarse sediment on adjacent flood plains (Gilbert, 1917; Collier, 1970; Osterkamp and others, 1984). Reduced infiltration capacities may lead to flashier hydrologic responses during rainfall events and increased peak discharge; where increased sediment transport capacity of the resulting flows exceeds the increase in sediment supplied to the channel system, channel widening may be accompanied by stream entrenchment rather than aggradation (Graf, 1979; Touysinhthiphonexay and Gardner, 1984).

Study area

Smoky Creek (drainage area = 85 km^2) is a tributary of the New River, which in turn drains into the Cumberland River and is located in the Cumberland Plateau of northeastern Tennessee (fig.1). The Smoky Creek basin is underlain by flat-lying Pennsylvanian shales with intercalated siltstones, sandstones, and coal beds (Avery and Luther, 1970). Where coal seams crop out on mountain slopes they are subject to surface or strip mining along the slope contour, creating benches and spoil banks that may alter hydrologic response of the land surface and contribute large amounts of sediment in headwater basins. Mountain slopes in the region typically are steep, averaging from 20 to 60 percent. Local relief from the channel to the basin divide is approximately 350 m and total basin relief is about 600 m.

Hydrology and sediment yield

Average daily discharge for the period of record (1976-1983) at the gage on Smoky Creek at Hembree (drainage area = 44.5 km^2) was 1.3 m^3/s and the average value of annual peak discharge was 91.5 m^3/s. Because the longest stream gage record in the Smoky Creek basin extends only from 1975 to 1983, hydrologic effects of strip mining must be inferred from other regional studies. Paired-basin studies indicate higher peak discharge and shorter lag times for the rising limb of the hydrograph in mined basins as compared with unmined basins (McCabe, 1970; Minear and Tschantz, 1974; Curtis, 1972, 1979). These results are consistent with a reduction of infiltration capacity in the basin. An additional study of paired basins in the Cumberland Plateau of Kentucky (Bryan and Hewlett, 1981) suggested that mining caused an increase in the runoff erosivity index of Williams (1972).

Published comparisons of mined and unmined basins in eastern Kentucky and northeastern Tennessee indicate that suspended sediment yields are higher in the mined basins by factors ranging from 50 to 200 (Collier, 1970; Osterkamp and others, 1984). Comparisons tabulated for this paper, including three locations in the Smoky Creek basin, indicate that suspended sediment yields in the mined basins are at least an order of magnitude greater than in the unmined basins (table 1).

Movement of tractive load also increases as a result of strip mining. This fraction of the total sediment load is not generally documented by routine suspended-sediment sampling but it plays a critical role in promoting bed aggradation, bar formation, and channel instability. Traction load accounts for at least 8 percent (65 t/km^2) and possibly as much as 10 to 15 percent of the total sediment discharge from the upper Smoky Creek basin (Osterkamp and others, 1984). An estimated 52 percent

THE SMOKY CREEK BASIN

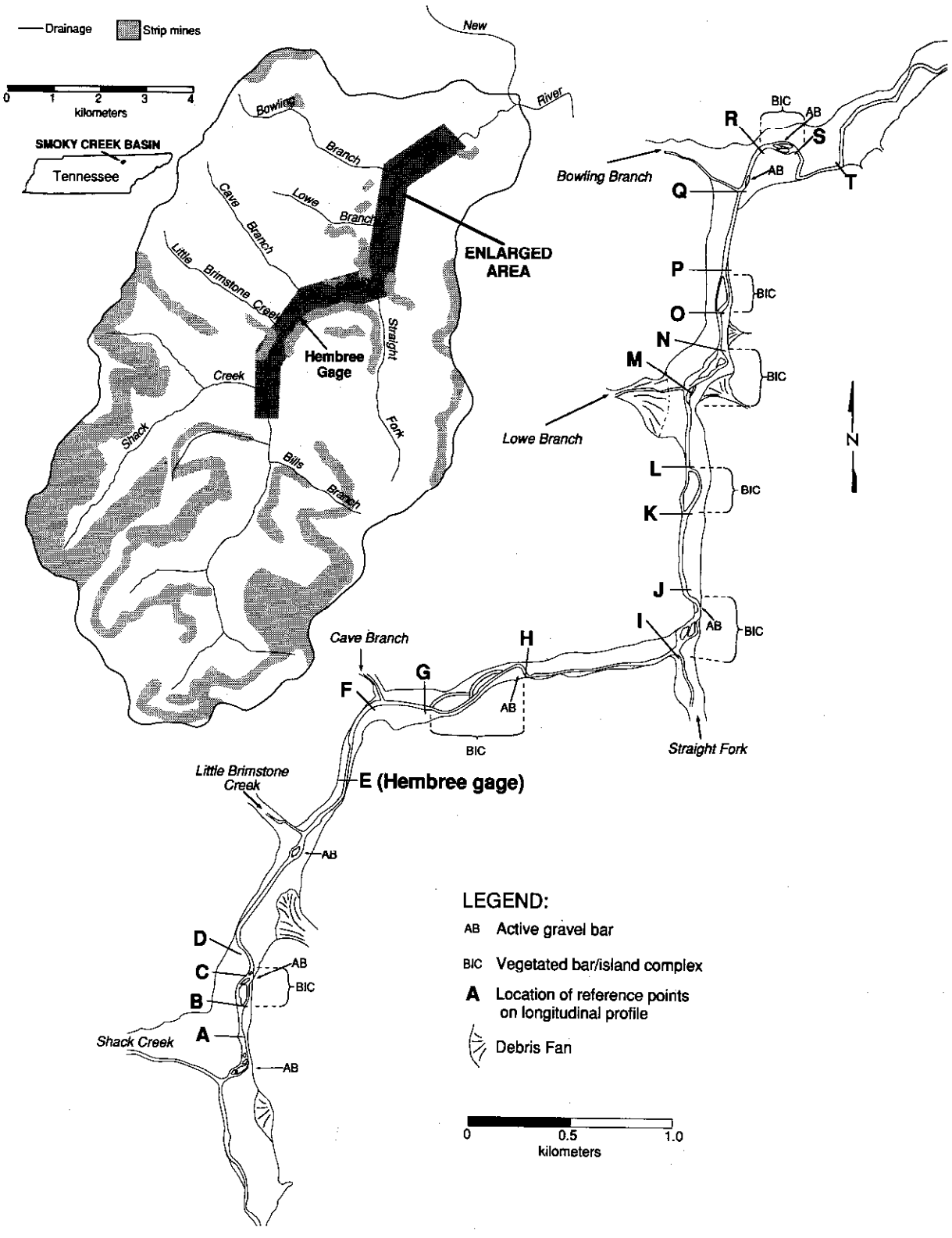

Figure 1. Location map of Smoky Creek basin with cartoon of valley floor showing major sites of deposition. Light shaded area on location map shows extent of active, abandoned, and reclaimed strip mines as of March 1983.

of the traction load is coal, indicating that mine spoil is the dominant sediment source. Because of its lower density, the coal fraction of the tractive load moves through the Smoky Creek basin more rapidly than the coarse rock debris.

Land-use history

Mining activity began in the early 1940's. The percent of basin area in active, abandoned, or reclaimed strip mines increased from less than 1% in 1941 to nearly 15% by 1983, with most of the increase occurring between 1968 and 1979. Mining practices probably were less considerate of environmental consequences prior to passage of the federal Surface Mining Control and Reclamation Act of 1977 than afterward, and thus would have generated more sediment per unit area of disturbed land. However, because of the lag time involved in flushing sediment out of the system, an immediate reduction in sediment load would not be expected even if the passage of the 1977 law caused a rapid change in management practices.

Only about 2-3 percent of basin area is devoted to agriculture, and this figure has not changed significantly over the last several decades. Prior to the onset of strip mining there was a period of timber harvesting in the earlier part of this century; there are no statistics on exactly how much of the timber in the basin was cut. The typical pattern followed by loggers in this part of Tennessee in the early years of this century was to cut all of the marketable timber as rapidly as possible. Steep skid roads were built to haul the lumber down the mountain; another common practice called "J-logging" involved construction of a chute that would allow large trains of logs to slide downslope along a bed of peeled logs, with a log landing at the bottom of the slope to absorb the impact. Slash debris left behind on the slopes often burned down to the mineral soil within a year after logging, leading to accelerated soil erosion (Donald Todd, resident of Wartburg, Tennessee, personal communication, 1990). Thus there is a strong likelihood that timber cutting in the Smoky Creek basin was associated with rapid erosion and large sediment yields. Large-scale timber harvesting apparently came to an end in the 1920's; after a major flood in 1929, the branch of the Tennessee Railroad used to carry timber out of the basin fell into disuse (Lanier, 1968).

Table 1. Comparison of sediment yields
Selected streams from the Cumberland Plateau of Tennessee

Basin	Drainage area (km^2)	Sediment yield (t/km^2)
Unmined		
West Fork Obey R. nr. Alpine	298	13
Clear Fork nr. Robbins	704	32
Crabapple Ck. nr. La Follette	2.8	30
Mined		
New R. at New River	989	348
Smoky Ck. at Hembree	44.5	758
Bills Branch (trib. to Smoky)	1.7	415
Shack Ck. (trib. to Smoky)	5.1	494

CHANNEL MORPHOLOGY

Smoky Creek occupies a narrow valley bounded by steep bedrock walls. Valley-floor width typically is less than 300 m and at some locations is less than 50 m. As Smoky Creek is constrained by its narrow valley from the free meandering pattern typical of many alluvial rivers, its channel pattern consists of a series of straight reaches alternating with short meandering reaches that usually coincide with a change in valley orientation or with a tributary confluence immediately upstream. Most of the meandering reaches include only one or two meander bends, and in many instances the concave bank of one or both bends abuts a bedrock wall. A pool-riffle sequence with a thalweg that meanders past alternating lateral bars is typical of the straight reaches. Channel instability occurs primarily at meander bends and is characterized by accumulation of large gravel bars, bank erosion and channel widening, and formation of anabranching channels that frequently shift location.

Deposition zones

For the purposes of this paper, major areas of sediment deposition and storage along Smoky Creek are assigned to two categories. Large active gravel bars are mostly unvegetated or colonized by woody plants no more than a few years old and are characterized by evidence of ongoing aggradation, lateral migration, or irregular episodes of cutting and filling in response to sediment transport by annual high flows. Surficial sediment is dominated by gravel but may include sand lenses; coal fragments are common and often occur in pockets or lenses, due to hydraulic sorting. Vegetated bar/island complexes are larger geomorphic features, typically consisting of multiple bars and islands covered by woody vegetation including mature trees; they are separated by anabranching channels, and individual bars or islands are frequently dissected by shallow overflow channels. The entire complex is inset at an elevation slightly lower than the main valley floor and at or above the highest elevation on nearby active gravel bars, and is bounded by a scarp leading up to the main level. Evidence of deposition during frequent high flow events is common but less pervasive than on the active bars, and recent deposits are dominated by sand.

Major deposition sites are located downstream of every tributary confluence shown (fig.1) with the exception of Little Brimstone Creek. In addition, a couple of the bar/island complexes are located about halfway between tributary confluences.

Thus the spatial pattern of deposition is influenced by local hydraulic conditions along the channel, as well as by locations of major sediment sources. Virtually all of the large active bars are found in close proximity to larger vegetated bars and islands. Downstream of point S on fig.1 there are no major bars or bar/island complexes.

Longitudinal profile

Average channel gradient along the reach illustrated in fig.2 is about 0.004. The longitudinal water-surface profile of Smoky Creek at base flow is strongly stepped. Three of the four tributary junctions along the surveyed portion of the channel downstream of point E are associated with a sharp break in slope (figs.1,2), which can be attributed to bed aggradation where an influx of coarse sediment locally exceeds the transport capacity of the main channel. The channel gradient along reaches occupied by bar-island complexes generally is steeper than along the straight reaches immediately upstream or downstream. For bar/island reaches shown in fig.1 (other than R-S, where the gradient was altered with a bulldozer two years before the 1985 survey), the ratios of gradient along the reach to gradient along the adjacent upstream and downstream reaches average 2.9 and 3.6, respectively.

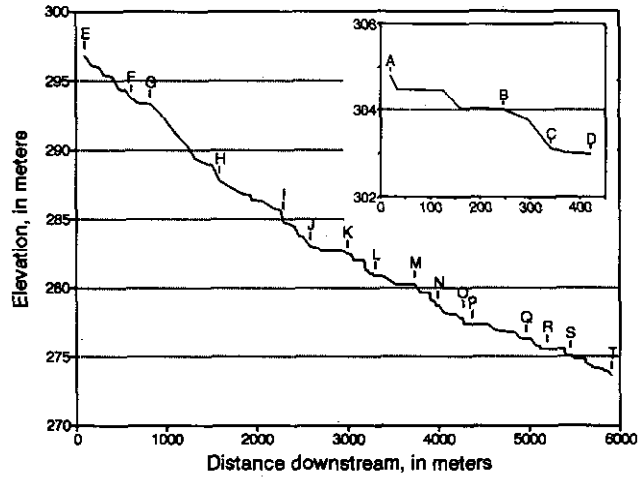

Figure 2. Longitudinal water-surface profile of Smoky Creek at low flow. Reference point locations are indicated in fig. 1. Profile of locations E-T surveyed August 1985; profile of locations A-D surveyed July 1988.

Cross-section characteristics

Of 10 monumented sections established in 1981 along the main channel of Smoky Creek, 7 were established at locations where the channel was straight, the top of the bank was reasonably well-defined, and the section was nearly trapezoidal. Three sections were established at locations with active gravel bars. Bankfull channel width at the straight sections ranged from 15 to 25 m and for 6 of the 7 sections the ratio of width to bankfull depth ranged from 9.1 to 12.4 (the ratio at the seventh section was 22.8). Bankfull width at the bar sites ranged from 30 to 70 m and width/depth ratio ranged from 12.5 to 28.5. Repeat surveys over a period of several years indicated much greater year-to-year variation and greater cumulative change at the cross-sections occupied by gravel bars than at the sites along straight reaches.

Table 2. Particle size and coal content of sediment samples

	% Gravel	% Sand	% (Silt+Clay)	% Coal
Channel bed matrix		Smoky Creek main channel (n=6)		
Average	82.9	16.7	0.4	1.2
Range	76.4-92.2	7.9-23.1	0.0-0.7	0.08-4.3
		Mined tributaries of Smoky Creek (n=3)		
Range	54.7-74.2	24.0-34.5	0.7-10.8	0.02-2.4
		Crabapple Branch (n=2)		
Range	87.8-92.2	7.8-12.0	0.0-0.2	0.0
Bank samples		Smoky Creek main channel (n=6)		
Average	10.1	55.3	34.4	2.3
Range	0.0-55.5	35.5-72.6	9.2-52.3	0.4-3.9
		Mined tributaries of Smoky Creek (n=4)		
Average	8.8	65.2	26.1	2.9
Range	0.4-29.4	60.1-74.5	6.4-37.6	0.3-3.8
		Crabapple Branch (n=4)		
Average	10.3	71.4	18.3	0.1
Range	7.3-12.6	65.4-77.4	15.2-22.0	0.0-0.3

Bed surface material at all of these cross-sections was a mixture of gravel, cobbles, and boulders. Bed matrix is dominated by gravel in all cases; most banks are composed primarily of silty sand, but some are mixtures of gravel and sand (table 2). Average coal content of samples from mined basins is lower in the bed material than in the bank sediments, but is quite variable in both cases; field observations indicate that its distribution on bars and in bank materials is patchy.

Sediments exposed on bar surfaces are composed primarily of gravel, but spatial patterns on individual bars are heterogeneous

owing to the combined influences of microtopography and vegetation on local patterns of erosion and deposition at high flow. Dendrogeomorphic evidence obtained at several sites indicates vertical accumulation rates up to about 30 cm/yr and lateral migration rates up to 1 m/yr during periods without major floods (B.A. Bryan and C.R. Hupp, U.S. Geological Survey, written communication, 1988). Field observations at the most active site along Smoky Creek indicate maximum bank erosion on the order of 10 m in a single year (fig. 3e), with vertical bar growth of up to 0.5 m.

DEVELOPMENT OF A BAR/ISLAND COMPLEX

A 50-year record of channel change at one site affected by recent bar growth and bank erosion was obtained using digital photogrammetric techniques (Miller, 1986). The observed series of changes may serve as an analogue to explain development of vegetated bar/island complexes elsewhere along the channel. The study site extends about 650 m downstream from the confluence with Bowling Branch. The sequence of changes, beginning with the earliest available aerial photographs, is illustrated in fig. 3. Areal extent of channel bars is not strictly comparable between dates, as the amount of the bed exposed to view varies with water level from one date to another. Nevertheless the shifting location of the major bars and the overall trend toward channel widening associated with progressive growth of the bar complex is clearly shown. Maximum bank retreat of 50 m occurred between 1971 and 1983 (figs. 3d,e).

The sequence of changes illustrates the downstream propagation of a wave of instability. In the summer of 1983, the property owner attempted to reclaim his land by scraping gravel out of the main series of bars and pushing it against the right bank, straightening the bank line. Although this stabilized the right bank temporarily, by 1987 the fill material was again being eroded. In addition the wave of instability had migrated around the bend and an entire new meander wavelenth was superimposed on a previously straight section of the channel (fig. 3f). Field measurements made along the right bank following conversations with the property owner during summer 1987 indicated that bank retreat of up to 10 m had occurred during spring 1987 at location 1 in fig. 3f.

The pattern of channel evolution at this site is heavily influenced by the role of vegetation in stabilizing bar surfaces and trapping fine sediment on the higher parts of bars. Rapid vertical accretion at sites of dense vegetation growth on the inner part of a bar can cause annealing of part of the bar to the flood plain. By 1987 the old bank line that formed the inner margin of the bar complex along the left side of the channel in 1983 (figs. 3e,f) was obscured by sediment accretion and vegetation growth and was very difficult to locate in the field. The cut bank that was visible when the site was visited in 1987 was cut into a vegetated surface that had accreted upward almost to the floodplain level since 1983. Extrapolation of deposition patterns observed between 1938 and 1989 suggests that as the wave of instability passes, bars and bar/island complexes will anneal to banks. This process results in a bottomland mosaic with scarps separating the younger from the older deposits in some cases and with no relief across the contact in other cases. The complex, episodic evolution of the flood plain would only be evident through detailed stratigraphic analysis or comparison of historical aerial photography.

Relation to strip-mine activity

Measured changes in channel width and in the position of the wave of instability indicate that the period of bar growth, accelerated bank erosion, and rapid downstream propagation of disturbance at the study site was contemporaneous with the increase in extent of upstream strip mining (fig. 4). The property owner claims that the hydrologic response of Smoky Creek during rainfall events has changed over the past several decades, with the creek rising more rapidly than it did in the past, overbank flow and sedimentation occurring more frequently, pools filling with gravel, and a general reduction in water depth. All of this is consistent with the evidence presented here. The amount of coal deposited on bar surfaces throughout the reach implies that strip mining has been the source of the sediment. Although there have been several large floods during the period of rapid bar growth and channel widening, one or two catastrophic events cannot account for the changes observed at this site; incremental changes have occurred during each time period for which information can be obtained.

CHANNEL INSTABILITY AT OTHER LOCATIONS

Dendrochronological evidence from three other active gravel bars along Smoky Creek also indicates that rapid bar growth has occurred during the past three decades, coinciding with the period of rapidly increasing mining activity (B.A. Bryan and C.R. Hupp, U.S. Geological Survey, written communication, 1988). At two of these locations, the stratigraphic sequence exposed in an eroding bank provides evidence that coarse sediments generated by mining activity have become annealed to the bank and incorporated in the flood plain.

A typical composite sequence based on observations of both profiles (at locations C and H in fig. 1) has the following characteristics: 0.15 to 0.45 m of brown fine sand, with organic litter at the surface and disseminated coal fragments; 0.6-0.9 m of cobbles and gravel, embedded in a matrix of brown sandy loam with abundant coal fragments up to cobble size; 0.3 m

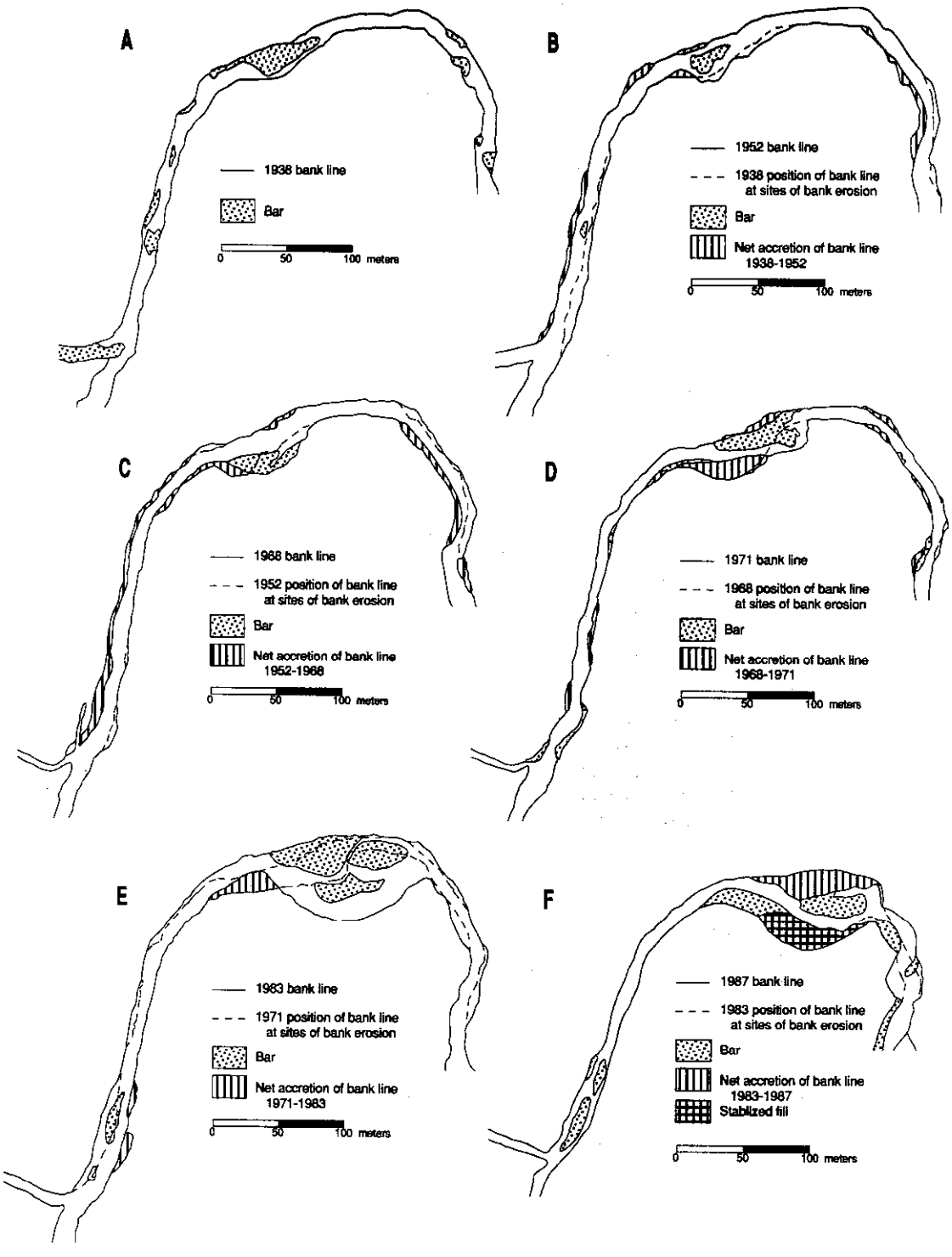

Figure 3. Channel changes on Smoky Creek downstream of Bowling Branch, 1938 - 1987.

of horizontally laminated sands and clays, with coal fragments in the sandy laminae; 0.15 m of gravel, cobbles, and coal fragments embedded in a sand matrix. The entire sequence is underlain by channel gravels at the base of the bank.

Excavation of root collars of buried trees and counting of rings from tilt sprouts of trees affected by flood damage indicates that the upper coal-rich cobble-gravel layer at one of these sites was deposited after 1958 and may have been deposited during a large flood that occurred in 1977 (B.A. Bryan and C.R. Hupp, U.S. Geological Survey, written communication, 1988). In both locations the coal-rich, poorly sorted deposits underlie a hummocky vegetated surface laterally and vertically inset against a flood plain or low terrace that is 0.5-1.5 m higher. Cut-bank exposures of the alluvium underlying this higher, older surface typically reveal a basal layer of channel gravels overlain by a fining-upward sequence of structureless silty sand.

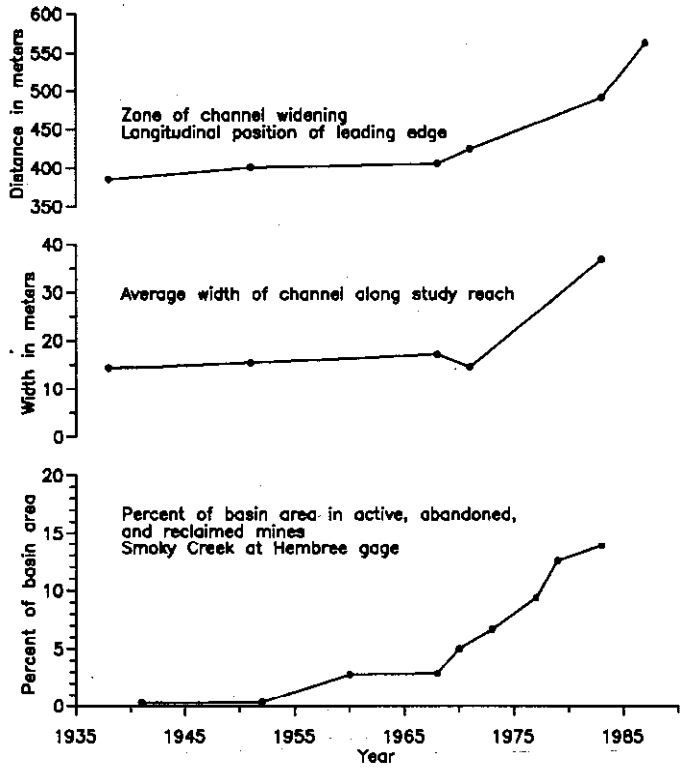

Figure 4. Comparison of channel changes at site downstream of Bowling Branch with historical trend in percent of basin area in strip mines.

In the absence of additional evidence one might reasonably conclude that the inset deposits are representative of vegetated bar/island complexes along the length of Smoky Creek, and that most of the major deposition features have formed during the period since strip mining began. However, sediments underlying some vegetated islands are better sorted and contain much less coal than modern sediments, suggesting deposition before strip mining began. Some of the trees growing on vegetated islands and bars are too old (up to 84 years, with some large rotting stumps that could not be dated but are probably older) to have germinated on a surface formed after strip mining began. Several of the vegetated bar/island complexes (as well as the large active gravel bar upstream of location J in fig. 1) are visible in aerial photographs taken in 1938 at the same locations that they occupy today.

At several locations along the channel of Smoky Creek there is a grey clayey sand, full of organic litter and wood fragments, overlying the basal channel deposits and underlying the silty sand that predates intensive strip mining. Large logs observed protruding from this layer clearly were buried in place rather than being pushed up against the base of the bank. Similar deposits can be observed forming today at locations where a muddy gravel mixed with leaf litter and wood fragments progrades into a deep pool or eddy along a low-gradient reach of the channel. At present there is no conclusive evidence to date the layer found at the base of the bank; but it seems plausible to attribute its formation to the period of timber cutting that occurred after 1912 and came to an end in 1929. This would have been the most significant episode of landscape disturbance to affect the Smoky Creek basin prior to the introduction of strip mining. Individuals who witnessed the impacts of logging in other nearby basins have commented on the tremendous amount of soil erosion that occurred on the steep mountain slopes and on the large amount of organic debris that accumulated in stream channels.

The implication of this observation is that some of the vegetated bar/island complexes may have formed during an aggradational phase associated with the period of timber cutting, and that these assumed a fairly stable configuration following the end of the logging operation and prior to the onset of strip mining. The vegetated bar/island complexes cover a much larger area than the large gravel bars that are presently active; thus, if they are attributable to a previous episode of erosive land use, that episode may have had an even greater net impact on the morphology of Smoky Creek than the more recent episode of strip mining. Alternatively, some of the vegetated bar/island complexes may be attributable to natural causes; stable patterns of islands separated by anastomosing channels may have formed at some locations along Smoky Creek before human activity played a significant role in altering the system. Further investigations of bank stratigrapby are needed in order to test

this hypothesis.

SUMMARY

Strip mining in the Smoky Creek basin has had a major impact on basin hydrology, sediment yield, and channel form. Along the main channel of Smoky Creek, these impacts include aggradation of the bed and filling of pools with gravel. Evidence of channel widening and instability is most prominent in distinct depositional zones that form below tributary junctions or at channel bends. A 50-year record of channel change at one of these sites shows that a wave of instability propagated downstream from the initial location of a channel bar present in 1938 (fig. 3a), and the timing of major adjustments appears to be linked to the increase in strip-mine activity from the 1960's through the early 1980's. Bar surfaces colonized by vegetation experienced rapid vertical accretion and in some cases were annealed to the bank within a few years. Viewing this sequence of events as an analogue, it is likely that the flood plain in some areas is a patchwork assembled through a series of discrete episodes of erosion and accretion.

Most of the large active gravel bars are found in association with vegetated bar/island complexes, which have hummocky surfaces and are laterally and vertically inset against a higher flood plain or low terrace. Cut bank exposures on some of these geomorphic features reveal stratigraphic evidence of rapid accumulation of coarse sediment during the period since intensive coal mining began. There is also evidence indicating that large bars and channel islands were present before strip mining began. Some of these may be attributable to bed aggradation and channel instability during the period of timber cutting between 1912 and 1929.

ACKNOWLEDGEMENTS

Photogrammetric measurements were made using the APPS-IV analytical stereoplotter at the U.S. Army's Engineering Topographic Laboratories in Ft. Belvoir, Va. Bradley Bryan assisted in the field and provided field notes from surveys completed prior to my involvement in the project. Discussions with Bradley Bryan, Cliff Hupp, Robb Jacobson, and Waite Osterkamp have contributed to my thinking on the topics addressed in this paper.

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STABILITY ANALYSIS OF NONCONNAH CREEK, MEMPHIS, TN

By Jerry W. Webb & David P. Berretta, U.S. Army Corps of Engineers, Memphis, TN and William A. Thomas, Waterways Experiment Station, Vicksburg, MS

INTRODUCTION

Purpose and Scope of the Study

The Nonconnah Creek Drainage Basin includes portions of Shelby and Fayette Counties in southwest Tennessee, and portions of Desoto and Marshall Counties in northwest Mississippi. Approximately one-half of Memphis, Tennessee, is located within this drainage basin which is one of the fastest urbanizing areas in western Tennessee. The basin is approximately 32 miles long, 8 miles wide, and generally rectangular in shape. The total drainage area of Nonconnah Creek is 117,000 acres (183.1 square miles). The stream slope is approximately 5 feet per mile with topography varying from gently rolling hills and ridges in the upland areas, to moderately wide valleys. This report describes the results of sedimentation and stability analysis performed during the evaluation of flood control alternatives. The design procedure and rationale for the design of this project are typical of most flood control projects with the exception of the high degree of protection that the existing channel provides. Special key issues that were of interest in this project include protective measures, water surface profile stability, and approach and exit channels. The proposed channel improvements have been designed using the guidance provided in ER 1110-2-1405 which states:

"The hydraulic design of a local flood protection project must result in a safe, efficient, reliable, and cost effective project with appropriate consideration of environmental and social aspects."

Physical Setting

Historically, Nonconnah Creek was a natural meandering stream, but commercial activities and increasing urbanization resulted in drastic changes in the streams configuration. The existing channel is rather narrow and deep and is bedded in sand or gravel throughout the study reaches. The banks are predominantly clay or silt, occasionally intermixed with a strata of sand. The upper reaches of Nonconnah Creek were modified by local interests over 50 years ago. Little is known as to the stability of the channel immediately following the channel improvements. Aerial photographs taken in 1958 show that a rather artificial looking channel had been cut through the meander traces even though the area south of Nonconnah Creek was practically undeveloped. At this time there were 15 bridges between the mouth and Winchester Road which consequently locked in the channel alignment. More recent aerial photographs show no trace of historical meander patterns and prove that the basin has urbanized at a rapid rate. Two areas, one located downstream of Perkins Road (Mile 11.53) and the other located downstream of Mt. Moriah Road (Mile 12.59), were extensively excavated for commercial development in the floodplain. Other locations have served to support mining operations. Although the stream was, and continues to be, highly disturbed by commercial activities, a low flow channel has formed alternate bars indicating a tendency to reestablish a meander pattern. In the early 1980's, the local governments began an extensive bridge monitoring and rehabilitation program after the catastrophic failure of one bridge

facility. Improvements consisted of riprap and gabion channel and bank protection around bridge facilities. These improvement not only are protecting the facilities, but are also serving as grade control structures.

STUDY APPROACH

This study utilizes a staged sedimentation study approach similar to the descriptions in EM 1110-2-4000. During the early stages of project formulation, there was little or no sediment data. Since the channel and floodplain have been so dramatically disturbed, calibration of a numerical model was not possible, and an initial sediment impact assessment was performed. Based on the results of that analysis and information gathered during the hydraulic studies, protective measures were designed for all structural components of the project. Subsequent to submission of the Phase II GDM, reviewing authorities required a detailed sedimentation study. The following paragraphs discuss available data, methodology, and results of both levels of the analysis.

Initial Assessment

Available Data during Initial Assessment

Data necessary for conducting the sedimentation study were of three types: geometric, sediment, and hydrologic. Visual inspections of the Nonconnah Creek basin also aided in the sediment study.

The geometric data consisted of channel cross sections which were obtained from field surveys. Analysis of aerial photographs, quadrangle maps, and proposed channel improvements were also used. From this data, bed profiles and channel alignments were obtained.

Sediment data consisted of the channel bed composition, the strata underlying the bed material, and the inflowing sediment load. Due to commercial activities throughout the basin, no bed samples were taken. Visual inspections were used in determining the bed composition. The existing bed consists of sands and gravels throughout the study reaches. Twenty-nine channel borings and associated grain size distribution curves were used to define the underlying strata and bed material.

The hydrologic data included extensive land use studies which indicated that the total basin is currently 43 percent urbanized with a projected increase to 66 percent by the year 2043. The basin area below John's Creek (Mile 11.94) is approximately 78 percent urbanized with a projected increase to 97 percent by the year 2043. The study area was modeled using the HEC-1 Flood Hydrograph computer package as part of the hydrologic and hydraulic analyses. The hydrologic studies estimate that these future projected increases in urbanization will increase the 100-year discharge by approximately 20 percent. For this level of study, the hypothetical discharges for a 2-year frequency event were multiplied by a range of ratios (25, 50, and 75 percent) to better evaluate in-bank flows under normal, daily conditions. These discharges were input into the hydraulic model to determine variables needed in this evaluation. Observed 24 hour rainfall from 1977 to 1986 was used in estimating the number of events per year that could be expected for a estimated discharge.

General Procedures Adopted in Initial Assessment

The following discussion addresses the initial assessment of channel stability with respect to the existing conditions and the recommended improvements. The stability analysis performed includes a qualitative and relative quantitative evaluation of potential problems and betterments resulting from proposed channel improvements. Representative channel reaches with respect to hydraulic characteristics were designated along Nonconnah Creek. Hydraulic, hydrologic, and geometric data were extracted from the HEC-1 and HEC-2 computer models for the 2-year frequency event and several lesser flows including ratios of 25, 50, and 75 percent. Average reach parameters were determined from actual parameters of the cross sections thru that reach. The total bed-material load for each reach for the different events was estimated using Toffaleti's Method as included in the Waterways Experiment Station (WES) program H0926, Corps Library for Hydraulic Design.

Results of Initial Assessment

The degree and location of channel aggradation and/or degradation and overall channel stability were evaluated by comparing the sediment transport for existing conditions with that under the proposed plan of improvement. The sediment transport capability derived from Toffaleti's Method was computed for each reach of channel for the 2-year frequency event and several more frequent events. These results present a snapshot of deposition and erosion rates and were used to estimate relative rates of scour and deposition (i.e. not long term volumes). Table 1 presents the results of the analysis.

Table 1
RATE OF SCOUR AND DEPOSITION

Stream Mile From (mi.)	Stream Mile To (mi.)	Reach	Existing Conditions Scour (ft/yr)	Existing Conditions Deposition (ft/yr)	Improved Conditions Scour (ft/yr)	Improved Conditions Deposition (ft/yr)
0.29	2.35	1	0.3-0.6		0.0-1.9	0.0-0.4
2.65	3.14	2	1.9-4.5		0.0-2.1	0.0-2.1
3.23	4.32	3	0.0-0.6	0.0-1.8	0.0-0.2	0.0-0.1
4.35	5.54	4	1.8-2.9		0.0-1.2	0.0-1.3
5.62	6.86	5		0.3-0.5	0.1-0.6	
6.90	7.63	6	2.5-5.0		0.0-1.2	0.0-1.2
7.78	8.09	7		1.2-3.2	0.0-1.2	0.0-0.2
8.18	10.35	8	0.4-1.0		0.2-0.5	
10.46	11.44	9		0.7-1.5		1.2-1.8
11.50	11.94	10	4.7-9.3		7.9-12.7	
12.02	12.46	11		0.3-0.9		0.7-1.3
12.63	14.37	12	0.0-0.2	0.0-0.1	0.0-0.1	0.0-0.2
14.46	15.53	13	0.3-0.6		0.3-0.9	
15.62	17.25	14	0.2-0.4		0.3-0.7	
17.37	21.01	15	----	----	-----	------

Based on historic information and field observations, the results in Table 1 give a good indication of existing conditions. Reaches 13 thru 15 have not experienced significant modifications over the past several years. Reach 12 has oscillatory tendencies; aggrading under certain flow conditions, and

degrading under other flow conditions. Reach 11 is a depositional reach and has been an active borrow area. Reach 10 is a very dynamic reach with active bank caving and erosion. This reach is critical in that commercial development has been allowed to encroach to topbank and Johns Creek, the major tributary, enters Nonconnah Creek in this reach and aggravates the problem. In August 1987, Reach 10 was extensively modified by a local developer. The channel bottom width was approximately doubled and the side slopes improved. The developer has implemented some bank stabilization measures. Reach 9 is also a depositional reach and has been an active borrow area. Reach 8 shows signs of instability through channel widening and bank caving. Reach 7 exhibits depositional tendencies which is substantiated by current dredging operations that have gone on for several years. Reaches 3 thru 6 show the same scouring and/or depositional tendencies as previously explained. Reaches 1 and 2 are located in the Mississippi River backwater areas. Results indicate headwater scouring; however, these reaches have been relatively stable over the past few years.

The proposed improvements give a relative indication of conditions after the project is in place and identified problem areas. Most reaches develop oscillatory tendencies seeking a state of quasi-equilibrium. Historic depositional reaches 9 and 11 will continue to follow this trend. Reach 10 shows an increase in scouring tendency which will require channel and bank stabilization. Otherwise, the responses to natural morphological changes would be propagated to reaches above and below and cause changes to their respective channel characteristics. The proposed improvements also recognize the need for increased channel stability around bridge structures and in certain bendways. Protection will be provided at all facilities as required by accepted criteria. This protection will also function as grade control of the channel. Bendways located between Mile 0.76 and Mile 0.94, Mile 4.77 and Mile 4.90, and the outlet channel for Nonconnah Pump Station will also be protected.

Interpretation of Results of Initial Assessment

In alluvial streams it is expected that banks will erode, sediment will be deposited, and floodplains and tributaries will undergo modification with time. The Nonconnah Creek basin in recent years has experienced rapid growth which has altered channel characteristics. Channel velocities are high, and man's activities have caused extensive instability. The proposed improvements will be constructed along the existing channel alignment. The improvements will essentially provide a consistent drainage system to convey future flows through the basin. From the initial sediment impact assessment, it was determined that impacts to the existing river morphology will consist of accentuating the oscillatory tendencies along various reaches of the channel.

Detailed Analytical Study

Available Data during Detailed Studies

Data necessary for conducting the sedimentation study were similar to the initial assessment and consisted of three general types: geometric, sediment, and hydrologic. This analysis utilized geometric data from the previous study.

Additional sediment data was taken in April 1988 when 54 sediment samples were taken from the channel bed at 27 locations spaced along the 20 mile study

area. Two samples were taken in the dry at each location, one from near the water's edge and the other from the point bar deposits midway of the channel. Grain size distribution curves were developed for the samples. In addition, channel borings and associated grain size distribution curves were used to define the underlying strata.

In order to develop a histogram for the detailed sediment model, rainfall - runoff simulations were generated using historical rainfall (1964-1987) observed at the National Weather Service Office at Memphis International Airport. The procedure used involved computation of composite unit hydrographs from the 10-year and 100-year flood hydrographs from the HEC-1 models. Daily discharges were computed using the observed rainfall applied to the composite unit hydrograph. The computation of daily discharge uses the antecedent precipitation index method to compute losses. This data was reduced to blocked histograms using the Sediment Weighted Histogram Generator (SWHG) developed by the Hydrologic Engineering Center, Davis, California. The program processes daily discharges into representative discharges and time periods. Histograms were computed at four locations for existing and improved conditions using Total Water Volume as a basis for proportioning tributary inflows.

General Procedures Adopted for Detailed Study

The following discussion addresses the analytical approach taken during the detailed studies of channel stability with respect to existing conditions and the recommended improvements. Following the initial assessment, a sedimentation study was performed by Mr. William A. Thomas, Hydraulics Laboratory, Waterways Experiment Station (WES) and personnel from Memphis District. The results of the study are published in Miscellaneous Paper HL-90-1 entitled "Nonconnah Creek Sedimentation Study Analysis Using A Numerical Modeling Approach," dated January 1990. These results are summarized in this section and serve as a basis for establishing operation and maintenance requirements of the project sponsors. The WES computer program, "Sedimentation in Stream Networks" (TABS-1) was used to investigate the adequacy of proposed channel invert controls by forecasting channel aggradation and degradation over the next 10 to 25 years. Nonconnah Creek has been disturbed too severely to permit the normal model confirmation. Therefore, the investigation used a long term runoff record developed from rainfall, and single event runoff hydrographs developed using HEC-1. The objective was to calculate the probable aggradation and degradation of the stream bed profile as the creek responded to the modeling approach. The model is unconfirmed, and consequently, the results do not meet standards associated with a numerical model. Therefore, the approach provided a theoretical treatment of the degradation/aggradation processes along Nonconnah Creek. It also provides a numerical model which could be confirmed if adequate field data were available. Finally, the approach utilized the fullest extent of present technology to study a project which involves mobile bed hydraulics and all the channel bed dynamics associated with fluvial processes.

Evaluation of Inflowing Sediment Load

No suspended sediment measurements are available, but sands and gravels are the predominant sediment sizes on the bed of the existing channel. Therefore, sediment transport theory was used to calculate the bed material sediment discharge for existing conditions. These calculations require hydraulic

parameters plus the gradation of the bed surface. The portion of Nonconnah Creek upstream from Winchester Road (Mile 18.10 to Mile 20.98) was selected for the transport capacity calculations. The existing conditions geometry and n-values formed the geometric model. Four flood discharges were selected, and the starting elevations for the water surface profiles were taken from the HEC-2 model. TABS-1 was used for the calculations.

Since the bed samples from "mid-bar locations" were the most likely to have been deposited during floods, they were used to describe the bed material for sediment transport calculations for the four selected flood discharges. Starting with the 2-year flood peak discharge, a zero sediment inflow was prescribed for the TABS-1 code. The Laursen Transport function as modified by Madden in 1985 was used to calculate the total sand and gravel load moving in the model and the concentration by size class. The average transport capacity was calculated by averaging the 11-cross sectional values from Mile 18.10 to Mile 20.98. Those values were then coded as the inflow to the upstream end of the model and the calculation repeated for that same water discharge. After three iterations, the inflow was in balance with the average transport in that reach as shown by a zero trapping efficiency and negligible bed change at each cross section. That value was selected; the next water discharge was prescribed and the procedure started over.

The sediment inflow from tributaries was assumed to be zero. This was based on the fact that no bars were found at the mouths of tributaries, and there was noticeable degradation downstream from existing drop structures on Johns Creek and Ten Mile Creek. There were no significant deposits within the concrete lined tributaries. This supported the assumption that no significant sediment load was being introduced by the tributaries. Also this assumption resulted in more erosion occurring in the model than would occur in the prototype.

Results of Detailed Analytical Study

With respect to predicted bed surface profiles, the existing profile was compared to the predicted profile calculated for the end of the 24 year period of analysis. A degradational trend is indicated through the study limits. It should be noted that the lower two miles are not representative of long term trends because of the influence of Mississippi River backwater. For improved conditions, it can be shown that the recommended improvements will make the Nonconnah Creek channel invert more stable than it would be without the project. This improvement is attributed to the localized grade control provided by the protective measures included as project features at bridges and pipelines.

Most of the major tributaries that enter Nonconnah Creek have been either concrete lined or stabilized with some type of stone protection. A reconnaissance of the major tributaries was made with a representative of the City of Memphis to assess the existing condition of each confluence, to discuss the proposed improvements along the main stem of Nonconnah Creek, and to agree on protection requirements. It was determined that the confluence with Days Creek, Mile 6.16, and Ten Mile Creek, Mile 9.46, will be protected as a part of the improvement to Nonconnah Creek, but no additional protection will be placed at other confluences.

Interpretation of Results of Analytical Study

Although this study predicts a degradational trend with the project in place, this study supports the fact that the project will provide a more stable channel than will exist without the project. The calculated bed change in the approach channel is less than 1 foot. This is attributed to the stone protection proposed at the bridge crossings for Winchester Road, Hacks Cross Road, and Forest Hill-Irene Road. The calculated water surface profiles show no appreciable base level lowering in the 3 miles of approach channel to the project. Nonconnah Creek empties into McKellar Lake which flows into the Mississippi River. Maintenance dredging is required at the mouth of Nonconnah Creek. From this study it can be inferred that the proposed project should decrease sediment outflow by 28 percent. This is a direct reduction of a major sediment source to the lake which should reduce maintenance dredging quantities for that portion of the navigation project. Within the limits of study, the calculated maximum amount of degradation is about the same with the project as without it. However, the average amount of degradation over the 18.2 mile project length is 1.5 feet with the project and 2.0 feet without the project for the 24 year period of analysis. These values show that the project will reduce the rate of bed degradation by 25 percent. The average amount of aggradation is 0.25 feet without the project and 0.20 feet with the project for a reduction of 20 percent.

There is every indication that degradational and aggradational trends will continue past the 24 year projection at no decrease in rates. In other words, in 50 years the average depth of degradation is expected to be 3 feet with the project and 4 feet without the project. Continued downcutting of the stream bed, either with or without the project, will eventually increase bank heights to produce instabilities. The project sponsor has been made aware that the project will not cause such a condition; however, the proposed design does not stabilize Nonconnah Creek to the point of preventing such a condition from occurring.

PROJECT PERFORMANCE AND SAFETY RECOMMENDATIONS

Existing and Future Stability of Project Features.

The recommended plan of improvement to be separately implemented by the Corps of Engineers includes features for flood control, fish and wildlife enhancement, and recreation. Flood control is the primary project purpose, and its implementation is separate from the two supplemental features. Flood control measures include improving the lower 18.2 miles of Nonconnah Creek, of which 10.5 miles will be channel clearing and snagging only, and the remaining 7.7 miles will be channel enlargement. This improvement will provide a 100-year frequency level of flood protection.

The stream bed profile is generally degrading as evidenced by gabions, and other types of grade stabilization at several bridges. However, the banks appear remarkably stable to be so high and steep. There is evidence of bank failure downstream of Getwell Road where banks are wet from seepage. Elsewhere, point bars have developed indicating the reestablishment of meander patterns in the straight channel alignment. The sedimentation study has shown that the project will make the Nonconnah Creek channel invert more stable than it would be without the project under both existing and future hydrologic

conditions described above. The calculated maximum amount of degradation is about the same with the project as without the project. However, the average amount of degradation over the 18.2 mile project length is 1.5 feet with the project and 2.0 feet without the project for the 24-year period used in the analysis. Continued downcutting of the stream bed, either with or without the project, will eventually increase bank heights to the point of failure.

CONCLUSIONS

The sedimentation studies define the damage potential and potential hazard to life, and provide essential information for local sponsors to assess the functionality of the project. The requirements of ER 1110-2-1405 have been met and guidance provided in the EM 1110-2-4000 have been utilized in developing the study methodology and procedure. The initial assessment was accurate with respect to relative trends, but was not detailed enough to fully define long term performance and reliability. The more detailed analytical analysis was considered necessary for use in establishing recommendations and/or requirements of project sponsors. Even though adequate field data could not be obtained to confirm the numerical model to normal standards, the study combined engineering judgment with a theoretical treatment of the degradation/aggradation processes along Nonconnah Creek. It utilized the fullest extent of present mobile boundary technology to study a project in which mobile bed hydraulics, and the channel bed dynamics associated with the fluvial processes, are expected to be highly significant during the life of the project.

The model results provided the basis for establishing guidelines for operation and maintenance of the project which were furnished to the project sponsor. Provisions of the proposed operation and maintenance agreements include:

1. A moratorium on mining until the monitoring program can establish a baseline condition from which future activities can be regulated.
2. Periodic inspections of the channel and appurtenant works made by the local sponsor or his representative prior to the beginning of the flood season and immediately following each major highwater period.
3. Preparation and submission of reports regarding the condition of the flood control project.
4. The establishment of an effective monitoring program. This program should include the establishment of permanent ranges along Nonconnah Creek at approximately ten key locations for making periodic surveys of channel cross-sections. This should allow comparisons of cross-sections over time to monitor scour and deposition, thalweg fluctuations, and changes in rating curves.

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CHANNEL RESPONSE IN CLAY SOILS TO DOWNSTREAM MODIFICATIONS

by Walter M. Linder, Chief, Hydrologic Engineering Branch,
U.S. Army Corps of Engineers, Kansas City, Missouri

ABSTRACT

A number of streams in the Kansas City District have experienced severe degradation in the form of channel deepening and widening as a result of downstream channel modifications. This has resulted in loss of agricultural lands and damage to public utilities and transportation facilities. Channel straightening and enlargement for purposes of flood control have been the primary causes. Degradation has occurred in clay soils that normally would be considered relatively erosion resistant. This paper describes changes that have occurred on several streams, causes of the degradation, predictions of future degradation and actions taken or proposed to prevent channel deterioration.

INTRODUCTION

It is a well known principle of geomorphology that lowering the water surface or increasing the flow velocity by channel modifications can have adverse consequences both upstream and downstream. This principle is frequently overlooked or disregarded. A common error is to assume that degradation will be minimal if the soils in the bed and banks of the stream are predominantly clays. In reality, the clay soils only modify the rate and type of erosion. Degradation in clay soils may be somewhat slower, but it frequently creates a deep channel that continually widens due to bank instability and failure as the channel becomes deeper.

SOLDIER CREEK

Physical Characteristics

Soldier Creek, a left bank tributary of the Kansas River, drains 330 square miles of dissected till plains in northeastern Kansas. The stream enters the Kansas River valley in the vicinity of Topeka, Kansas and flows along the left or north edge of the valley for approximately 8 miles before entering the Kansas River. Silver Lake Ditch, a major right bank tributary, joins Soldier Creek near its entrance on the Kansas River valley. A second large tributary, Little Soldier Creek, enters from the left bank approximately 3 miles upstream of Silver Lake Ditch.

The upper 30 feet (ft.) of the Soldier Creek valley alluvium consists of lean to fat clays with a predominance of fat clays. Up to 30 ft. of silty sands and gravels underlie the clays. The average depth to the underlying sands in the Kansas River valley is somewhat less and averages 25 ft. The underlying bedrock consists of clay shales, siltstones, sandstone and limestone.

History

Numerous channel modifications for purposes of flood control were made in the lower reaches of Soldier Creek. Sometime prior to 1933 the length of the channel was shortened by approximately one-third in the 5-mile reach downstream of its entrance on the Kansas River flood plain. This same reach of

channel was shortened to about 60 percent of its original length by 1950. Cross section surveys in 1933 and 1958 indicate this channel straightening did not cause significant channel changes.

The Corps of Engineers constructed the Soldier Creek Diversion Unit between 1957 and 1961 as part of the Topeka, Kansas, flood control project. This work consisted of additional channel straightening, channel enlargement and construction of levees along the lower 10 miles of the stream. The straightening further reduced the length of the lower Soldier Creek channel to about 50 percent of its pre 1933 length. The junction with the Kansas River was also relocated farther downstream on the Kansas River. However, this did not result in any significant change in channel length. The modified bed slope was 0.00026 (1.37 ft./mi.) for the downstream first mile and flattened to 0.00003 (0.16 ft./mi.) for the next 3 miles. The slope was steepened to 0.001 (5.28 ft./mi.) for the next 3 miles. Bed slopes for the remaining 2.5 miles of the project varied from 0.0006 (3.17 ft./mi.) to a maximum of 0.001. The enlargement consisted of a 100-foot bottom width channel with 1V on 2H side slopes from the Kansas River upstream to Silver Lake Ditch. At Silver Lake Ditch the bottom width was narrowed to 40 ft. for the remaining 2 miles. Depth of the modified channel below natural ground varied from 20 to 28 ft. Continuous rock slope protection was provided on both sides of the modified channel for the lower 4.5 miles. Slope protection in the upstream portion was provided only at bridges and adjacent to tributary mouths. The design discharge was 50,000 cubic feet per second (c.f.s.). This provided 200-year flood protection for over 5,000 acres of agricultural, commercial and residential lands.

Channel deepening and widening started within a few years after completion of construction. Surveys in 1969 and 1972 showed the bottom had lowered 4 ft. just downstream of Silver Lake Ditch and 4 to 6 ft. near the upstream end of the project. Very little widening occurred in the 100-foot bottom width channel below Silver Lake Ditch. Upstream of Silver Lake Ditch the bottom width increased from 40 to between 50 and 70 ft. Degradation extended over 4 miles upstream of the project by 1984.

The Union Pacific Railroad parallels the right edge of the lower Big Soldier Creek valley for a distance of about 5 miles. The tracks then follow the center of the valley and cross the channel twice before leaving the valley about 3 miles farther upstream. Within this 8 mile reach the channel is adjacent to the railroad at six locations. At four of these locations channel degradation seriously threatens the stability of the road bed. The tracks also cross several small tributaries where degradation threatens the stability of the tributary bridges. The railroad has attempted to stabilize the channel slopes adjacent to the tracks with large rock and timber piling. However, these efforts have not been entirely successful.

Construction of a multipurpose dam was proposed at a location just below the confluence of Soldier and Little Soldier Creek. This dam may have reduced or eliminated degradation problems on Soldier Creek. However, the project did not receive the required local support and it was deauthorized by the 1986 Water Resources Development Act.

The project sponsor has expended considerable effort in attempting to control degradation. This has consisted of repairing slide areas, placing heavy rock

and rubble toes at the base of unstable side slopes, and constructing several rock and rubble grade control structures under bridges and at other critical locations. These efforts have been quite successful in preventing degradation from becoming totally out of control.

Degradation Study

Because of concerns expressed by the project sponsor and the Union Pacific Railroad, a study was initiated to determine if there might be a feasible solution to controlling the degradation. The reach considered in the study extended approximately 16 miles upstream from just below the junction of Soldier Creek with the Kansas River valley. The study was essentially confined to the Big Soldier Creek channel since there was only a limited amount of data available for Little Soldier Creek.

Bed or low water profiles plotted from cross section data showed 10 or more feet of degradation by 1984 in the first 6 miles upstream of Silver Lake Ditch. Substantial degradation extended farther upstream, but the actual extent was unknown because of lack of historic data. It appeared some degradation extended to the upstream railroad crossing, more than 5 miles above the upstream end of channel modifications.

Several sets of cross section survey data were available for comparison at three locations between Silver Lake Ditch and the upstream end of the channel modification. These included two surveys prior to construction of the channel modification and two surveys after construction. A 1933 survey indicated top widths averaging 110 ft. with bottom widths of 10 to 15 ft. Surveys prior to construction of the project indicated only minor changes occurred between 1933 and 1958. Surveys in 1969 indicated significant enlargement of the channel. Bottom widths had increased from 40 ft. to between 65 and 70 ft. and top widths from 140 to about 180 ft.

Channel top and bottom widths were plotted against depth using cross section data spanning a period of years prior to and after construction. These plots showed a reasonably consistent relationship between the parameters. An eye fit upper envelope curve was defined and used to predict probable future channel dimensions with continued degradation.

The plasticity index versus liquid limit was plotted using data from previous soil borings obtained near the channel. Comparison of the plotted points with trends of erosion characteristics for fine grained cohesive soils, presented by Gibbs in a U.S. Bureau of Reclamation report, indicated the soils in the bed and banks of Soldier Creek should be quite resistant to erosion. However, the data also indicated expansive characteristics of the soil. This indicates that during low-flow periods the soils in the banks shrink and crack with drying, allowing removal of surface soils during the next high flow event. The side slopes also become unstable and slump with continued deepening providing more material for removal by high flows.

Future Conditions

A tractive force approach was tried in an attempt to determine if a future stable channel dimension and slope could be achieved. Tractive force versus discharge relationships were developed for three typical channel cross sec-

tions using depths and velocities derived from water surface profile computations with and without grade control structures. The results gave a wide range of permissible forces indicating either a stable channel condition could not be obtained or the channel was already stable. Since this approach was inconclusive, no further attempt was made to use a tractive force method.

A number of channel controls in the form of rock and rubble sills and valley wall contacts occur within the study reach. Field reconnaissance verified the stream either flows over a rock outcrop or there are extensive rock and gravel bars over a significant length of the channel at each of the valley wall contacts. These controls will exert a significant influence on future channel changes. In long reaches without controls, the channel can be expected to continue to degrade in an attempt to achieve a more stable condition. Some additional deepening will occur at locations of rock outcrops because of the poor quality of the rock. The channel may also continue to widen in these areas as one bank is generally free to continue eroding.

A future bed profile was estimated considering existing bed controls, bed gradients prior to degradation, and channel characteristics within reaches between controls. Future channel dimensions were estimated using depths determined from the future bed profile and the relationships developed between channel depth and channel top and bottom widths. An estimate of future land loss was developed by multiplying the average increase in top width by the length of the study reach and converting the resulting area to acres. These estimates indicated that 5 to 10 feet of additional degradation could ultimately extend from the upstream end of the modified channel to the upstream end of the study reach. This would result in nearly 200 additional acres of land loss, failure of the railroad grade at several locations, and severe damage to county roads, bridges and culverts at numerous locations either on the main or tributary channels.

Potential Solutions

Solutions proposed for stabilizing the existing channel and preventing additional upstream degradation consist of grade control structures and bank protection. Two grade control structures are being considered, one located just below the junction of Big and Little Soldier Creeks and the other just below the downstream-most railroad crossing of Soldier Creek. The structure below the junction of Big and Little Soldier Creeks would stabilize the channel through three county road bridges and the location of the most severe area of instability adjacent to the railroad. The upstream structure would prevent degradation from extending farther upstream. The structures would be the baffled chute type because of their ability to function effectively with additional downstream degradation. Rock revetments would be used to stabilize areas where the degradation is threatening the railroad and county roads and bridges. Implementation of these proposals will depend upon the results of further studies and cost sharing by a local sponsor.

SHOAL CREEK

History

Shoal Creek, a right bank tributary of the Chariton River, drains 178 square miles of agricultural land in south central Iowa and northern Missouri. It

presently joins the Chariton River a few miles south of the Iowa-Missouri border. It previously followed a former channel of the Chariton River approximately 5 miles before joining the Chariton River which was straightened many years ago by local drainage districts.

The 1965 Flood Control Act authorized the Corps of Engineers to enlarge and straighten the lower 2 miles of Shoal Creek to an alignment directly to the Chariton River. Design studies in 1966 and 1967 proposed a 20 ft. bottom width channel with 1V on 3H side slopes. The proposed bed grade was 0.0004 (2.11 ft./mi.) for the upstream 2,300 feet and then steepened to 0.0014 (7.25 ft./mile) for the remaining 9,000 feet to the Chariton River. This bed grade would have entered the Chariton River about 2 ft. above the flow line of that stream. Five soil borings were obtained along the proposed alignment. One boring indicated highly erodible silts, one lean clay, and the remaining three were heavy or fat clays. Since the proposed slope was quite steep, constructing a pilot channel and letting the channel further enlarge by erosion was considered. However, it was concluded the soils were too erosion resistant for a pilot channel to be effective.

Environmental concerns related to maintaining low flows in the former Chariton River channel resulted in major changes to the final design. The project as built consisted of a 30-foot bottom width channel with 1V on 2H side slopes for the upstream 8,000 ft. The depth of this portion averaged about 12 ft. A high flow cutoff extended another 3,900 feet directly to the Chariton River. This high flow cutoff had a 60-foot bottom width with 1V on 2H side slopes. Depth below adjacent low spoil bank levees was about 10 ft. The entrance to the high flow cutoff was 5.5 ft. above the upstream flow line. At its downstream end the invert was 10.5 ft. above the flow line of the Chariton River. A large structural plate pipe was placed in the right bank just upstream of the high flow cutoff and a small channel excavated to the former Chariton River channel. The higher bed elevation of the cutoff channel was intended to divert low flows through the pipe into the former channel of the Chariton River. Flows in excess of the pipe capacity would pass down the high flow cutoff into the Chariton River. A sheet piling and rock grade control structure was proposed near the upstream end of the high flow cutoff. This was modified to a 10-foot wide, 3-foot thick layer of rock across the channel with the top of the rock flush with the channel bottom. A 2-foot thick layer extended up the side slopes. The design discharge was 3,500 c.f.s., slightly greater than the estimated average annual discharge. The project provided flood protection for 4,200 acres of farmland, most of which was located in the Chariton River flood plain. Construction started in the spring of 1974 and was completed in the fall of 1975.

Severe erosion of the high flow cutoff started in May 1975 before construction was complete. Erosion started at the Chariton River as a 6 to 7-foot high head cut and by July had proceeded 1,600 feet upstream. During one period, 500 ft. of head cutting occurred in 16 days. In less than 2 years the headcut progressed completely through the high flow channel. Surveys in November 1980 showed 8 to 10 ft. of degradation had occurred in the high flow channel, with 4 to 5 ft. of degradation extending to the upstream end of the project. The top and bottom widths of the high flow channel had increased by about 10 ft. Upstream of the high flow cutoff, channel widths had increased about 25 ft. Erosion undermined the low flow diversion pipe to the extent that the upstream portion of the pipe collapsed into the channel. Severe head cutting also

extended up the ditches at the highway crossing the upstream end of the project. Recent inspections indicate the channel below the highway bridge may be stabilizing, as vegetation is developing on the lower channel side slopes. However, active erosion extends nearly one-half mile upstream of the project.

Causes of Erosion

Numerous reasons were given for the rapid erosion. The area where the high flow channel was located was swampy and the soils had a high initial moisture content. One opinion was that drying of the soils was accompanied by considerable shrinkage and cracking. This allowed the flow to pluck out and erode dry clay blocks rather than remove individual soil particles from a homogeneous mass. This may account for the manner in which the head cutting occurred. However, the basic cause was the 10.5-foot of vertical drop in bed grade into the Chariton River at the downstream end of the high flow channel. Construction of an adequate grade control structure at this location would have prevented the head cutting and the project would have functioned as intended. However, the cost of an adequate structure may have made the project economically infeasible. The Missouri Department of Natural Resources has expressed concerns over the project's failure to maintain flows in the former channel. Unfortunately there is no longer a practical or economical way to accomplish this. The project presently provides a far greater degree of flood control than originally intended, and at the present time there are no plans for corrective action.

LITTLE BLUE RIVER

Description

The Little Blue River, a right bank tributary of the Missouri River, drains 224 square miles of rolling terrain at the eastern edge of the Kansas City metropolitan area. The lower 7 miles of the stream are confined by the Missouri River bluffs on the right bank and by part of the Missouri River levee system on the left bank. The stream follows an ancient channel of the Missouri River for the next 6 miles upstream. The valley soils are predominately clays which extend to the underlying bedrock, except in the area where the stream follows the former Missouri River channel. In that area, the surface soils are underlain by sand at a depth of 16 to 28 ft. In the downstream half of this 6 mile reach the lower portion of the channel is located in the underlying sand.

Channel Modification

Between 1975 and 1981 a 20-mile reach of the stream, starting from the Missouri River tieback levee, was modified to provide flood control for the Little Blue valley. The project was designed to contain the 100-year flood in conjunction with two upstream multipurpose lakes. The design discharge varied from 18,000 c.f.s. at the downstream end to 11,200 c.f.s. at the upstream end. The modified channel was also designed to minimize adverse environmental impacts. This was accomplished by the use of a composite channel shape consisting of a low flow channel with high flow berms 5 feet above the low flow channel bottom. The project sponsor has provided additional environmental enhancement by purchasing and maintaining a green belt or parkway along both sides of the modified channel for its entire length. Wherever possible, one

bank was left undisturbed by limiting excavation for the high flow berm to only one side of the existing channel. Excavation of the high flow berm was also switched to alternate sides. High flow channels, also 5 ft. above the low flow invert, were cut across existing channel loops. Sheet pile and rock control sills were used at the downstream ends of the high flow cutoffs to maintain normal flows in the natural channel and to prevent head cutting through the high flow channel. Excavated low flow channel bottom widths varied from 30 ft. at the downstream end to 10 ft. at the upstream end. Side slopes of the low flow channel were 1V on 2H. The high flow berms varied in width from 10 to 40 ft. where excavated on each side of the low flow channel and from 25 to about 80 ft. where excavated on one side only. High flow channel cutoffs had bottom widths varying from 50 to 80 ft. Side slopes of the high flow cutoffs and berms were 1V on 3.5H. The slope of the high flow channel varied between 0.00046 and 0.0007 (2.45 and 3.7 ft./mi.). The high flow cutoffs and the elimination of a limited number of meander loops reduced the travel distance for high flows about 30 percent or from 20.4 to 14.4 miles.

Six sheet pile and rock grade control structures were constructed in the low flow channel in the lower 4 miles of the project to prevent degradation in the area where the channel extended into the underlying sand. Each structure provided a 2 foot drop in the channel flow line. Several structures also served to protect existing pipelines that crossed under the stream. Rock riprap was used on one or both side slopes of the low flow channel in the same reach. In areas where the sand was above the level of the high flow berm, the side slopes were protected with riprap, and the sand on the horizontal portion of the berm was covered with several feet of compacted clay. Riprap was also used on the side slopes of both the high and low flow channels through bridges.

A reinforced concrete grade control structure was built at the upstream end of the modified channel to prevent upstream channel degradation. The structure consists of a 61-foot wide vertical weir with the crest 9 ft. above the upstream channel flow line. A 61-foot long stilling basin downstream of the weir with a floor elevation 2.75 ft. below the upstream flow line and a 2.75-foot high end sill provides for energy dissipation. The upstream head walls are 29.25 ft. above the stilling basin floor and several feet above the adjacent left overbank. The right head wall ties into the valley wall and a low berm extends from the left head wall several hundred feet laterally across the left overbank. Flows that exceed the design capacity of the structure can bypass around the left overbank and return to the downstream channel some distance below the structure. This prevents the structure from being damaged by flows overtopping the headwalls and washing out the backfill adjacent to the basin sidewalls. A short section of expanded channel was constructed downstream of the stilling basin and the side slopes adjacent to and for 200 ft. downstream were protected with heavy rock riprap. Ponding of water in the upstream channel is prevented by a 4-foot wide slot that extends from the center of the weir crest down to the flow line of the upstream channel.

Project Performance

The project has experienced several flows that approached and greatly exceed the design discharge. Prior to completion of the channel modification, heavy rains in the Kansas City area in September 1977 resulted in a discharge of

17,000 c.f.s. at the downstream end of the channel modification. This was only 1,000 c.f.s. less than the 100-year design discharge. In August 1982, after completion of the channel modification and prior to completion of the dams, the lower end of the project experienced a discharge of 42,300 c.f.s., nearly 10,000 c.f.s. greater than a 500-year discharge of 31,500 c.f.s. Damage to the project in both events was limited to minor erosion of the high flow berms and a few areas of bank erosion.

The grade control structure at the upstream end of the channel modification has performed its intended function extremely well. There has been no degradation of the upstream channel, and the slot in the weir crest has prevented the formation of sediment deposits upstream of the structure. The high flows in 1982 nearly overtopped the structure headwalls, and a minor amount of flow bypassed around the berm on the left overbank. However, there was no erosion where overbank flows returned to the downstream channel.

The project sponsor failed to adequately maintain the project for several years in the mid 1980s. For a period of about 3 years the high flow berms and high flow cutoff channels were not mowed. This resulted in extensive growth of vegetation and a significant amount of sediment deposition in some areas. This has caused some loss of project capacity. Failure to remove accumulated drift and debris in the natural channel meanders resulted in sediment deposits that blocked the entrances to several meanders. At these locations the low flow follows the high flow cutoffs. The structures at the downstream ends of the high flow cutoffs have prevented head cutting through the cutoffs. Some erosion and enlargement of the low flow channel has occurred. However, this has not been serious enough to be of concern. In general it can be concluded that the project has performed very well in providing flood control and minimizing adverse environmental impacts.

CONCLUSIONS

Whenever channel modifications are proposed, the designer must consider the potential for upstream degradation. Even though the soils are relatively erosion resistant, the ultimate consequences can be as severe as in the case of more erodible soils. The use of a composite channel shape with high flow berms and cutoffs can minimize adverse environmental impacts and channel instability within the modified reach. Care should be taken that the high flow berms are not so low that they are frequently inundated and thus become so wet that they are difficult to maintain. Grade control can prevent degradation within and upstream of channel modifications.

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NAPA RIVER SEDIMENT STUDIES WORK PLAN

By C.G. Wolff, M.R. Peterson, Hydraulic Engineers, Water Engineering and Technology, Inc. Fort Collins, CO, and M. Deering, Hydraulic Engineer, U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA

ABSTRACT

The Napa River Flood Control Project that extends from Edgerley Island (RM 6) to Trancas Road bridge (RM 17.3) is designed to provide 100-year flood protection. Frequent flooding in the past has caused severe damage to both agricultural and urban developments. A Sediment Studies Work Plan (SSWP) was developed to address: 1) the impact of sediment on project performance, and 2) the impact of the project on the behavior of the stream system and the limits of the project's influence on the morphology of the stream system.

Under pre-project conditions, the channel within the project reach shows no signs of accelerated erosion even though the channel has been subjected to: 1) dredging and bend cutoffs as a result of the implementation of a navigation channel in 1950, and 2) sand and gravel mining. The lack of adverse channel response can be attributed to the erosion resistance of the channel perimeter sediments. The historical need for maintenance dredging of the navigation channel shows that significant aggradation problems exist in the lower end of the project reach, which is tidally influenced. The problems are the result of upstream channel degradation and high watershed sediment yield. The cause of upstream channel degradation is unknown but could be due to a combination of downstream channel dredging, channel maintenance activities, and land use changes in the watershed. The development of hillside vineyards has increased watershed sediment yield significantly.

Under project conditions, cutoff of the channel bendway between RM 14.7 and RM 15.6 will increase the potential for degradation in the channel upstream of the cutoff, resulting in a significant increase in the aggradation problem downstream of the cutoff. A bed stabilization structure located upstream of the proposed cutoff would limit degradation in the upstream portion of the project reach and mitigate project impacts upstream of the project limits.

INTRODUCTION

Napa River, located in Napa County, California (Fig. 1), has a long history of flooding that has resulted in severe damage to agricultural and urban developments. The Napa River Flood Control Project, as described in the 1975 General Design Memorandum (GDM) (COE, 1975), is designed to provide 100-year flood protection in the study reach (RM 6 to RM 17.3) (Fig. 2). The current plan as proposed by the Corps of Engineers includes channel improvements from John F. Kennedy Memorial Park (RM 11.8) to the Trancas Road bridge (RM 17.3). The improvements will consist of channel excavation and setback levees and floodwalls from the downstream end (RM 11.8) to the confluence with Napa Creek (RM 14.7). The bendway between RM 14.7 and RM 15.6 will be cut off. Upstream of the proposed cutoff (RM 15.6), levees and floodwalls will be constructed as needed to protect developments on the west side of the river. Although not a part of the original flood control project as described in the 1975 GDM, channel improvements are proposed for Napa Creek extending from Jefferson Street to the confluence with Napa River (Fig. 3). Channel improvements on Napa Creek will consist of channel excavation, bridge removal and construction of a box culvert bypass channel.

A Sediment Studies Work Plan (SSWP) was developed to address: 1) the impact of sediment on project performance, and 2) the impact of the project on the behavior of the stream system and the limits of the project's influence on the morphology of the stream system. The study was divided into three phases: 1) field data collection and geomorphic analysis of the pre-project channel conditions, 2) sediment transport analysis of pre-project conditions and development of stable channel design criteria, and 3) sediment transport analysis and evaluation of the proposed project design with development of design changes based on project performance. The work was performed by Water Engineering & Technology, Inc. under contract to the U.S. Army Corps of Engineers, Sacramento District.

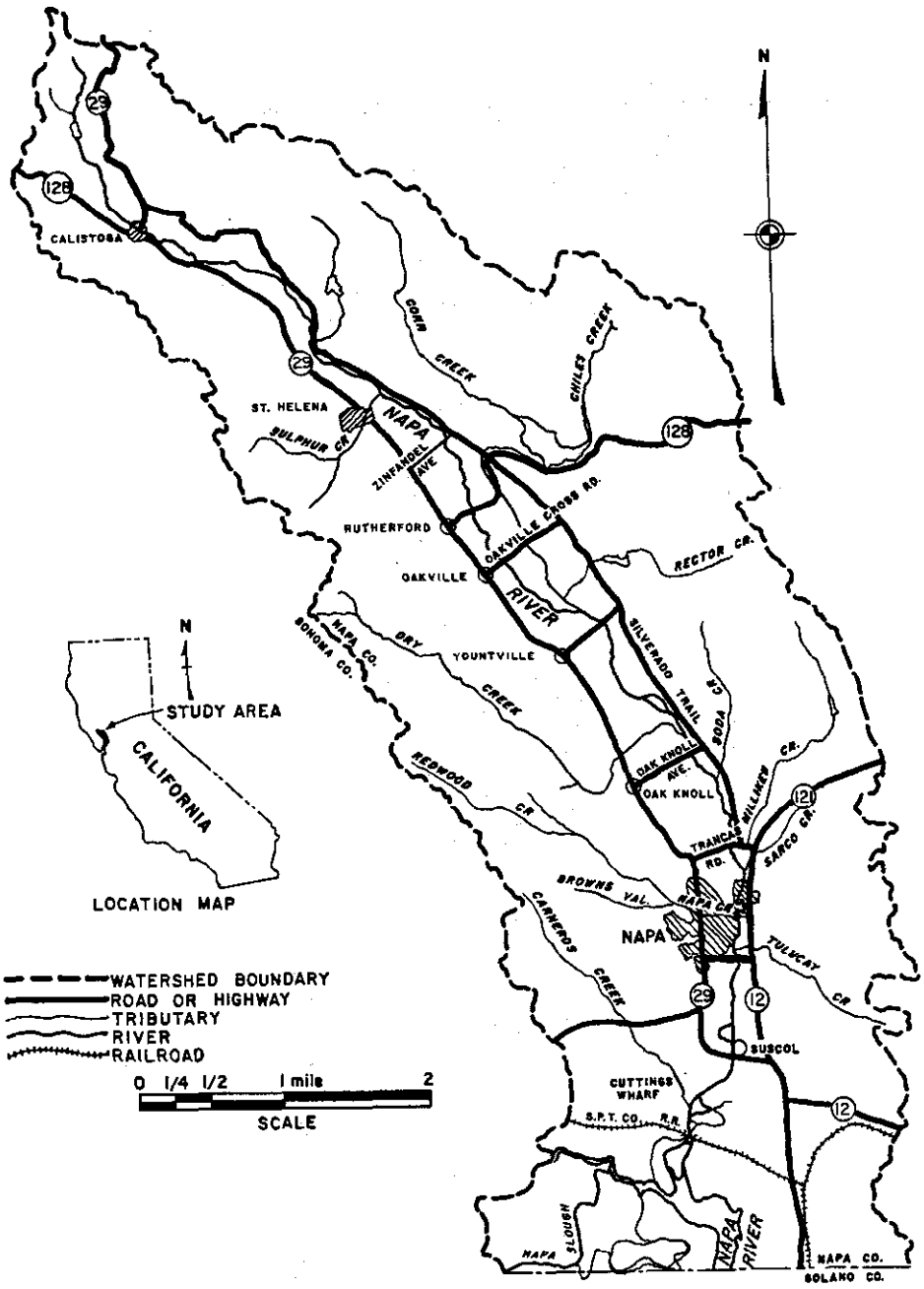

Figure 1. General location map for Napa River Flood Control Project.

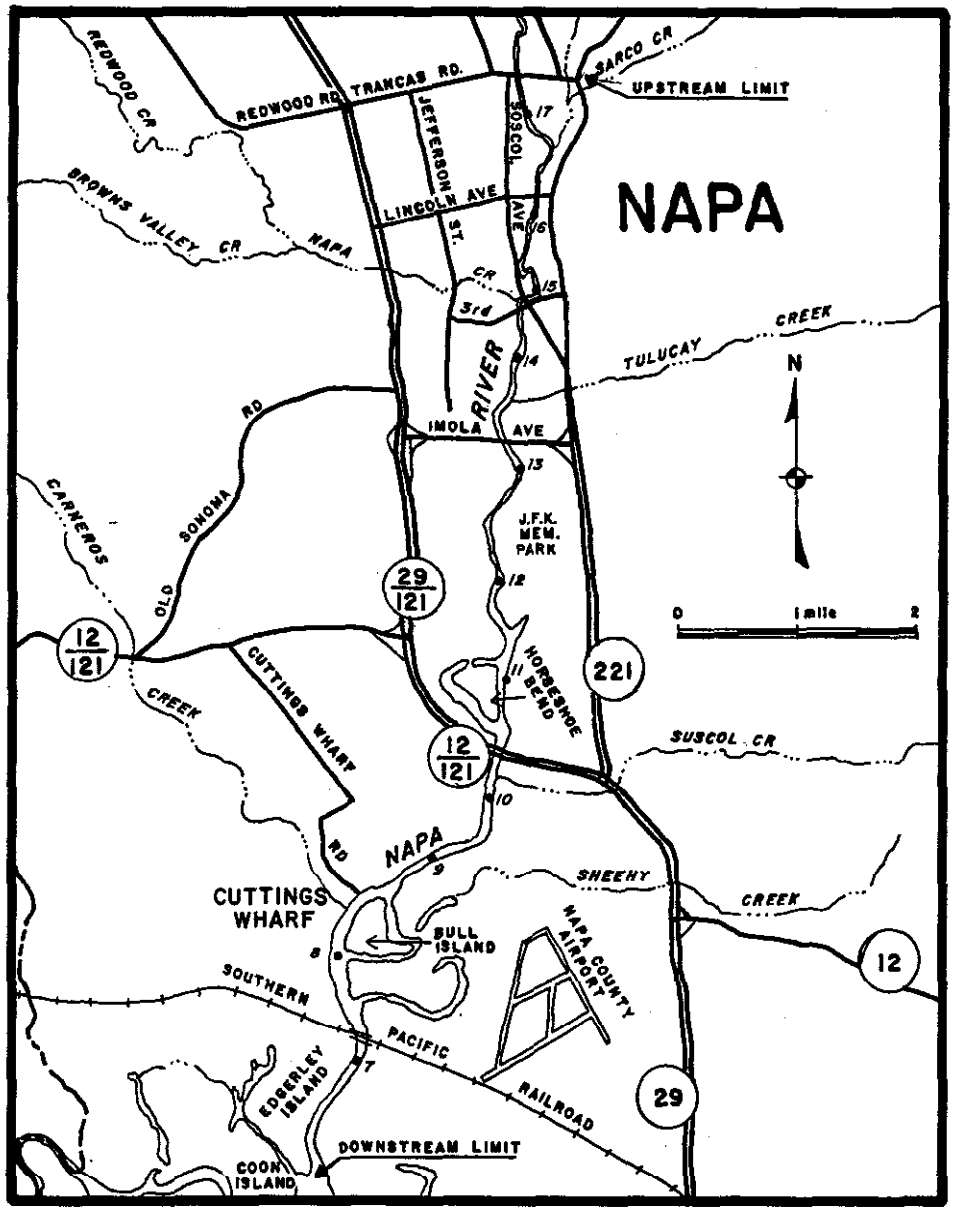

Figure 2. Location map for study reach of Napa River, RM 6 to RM 17.3.

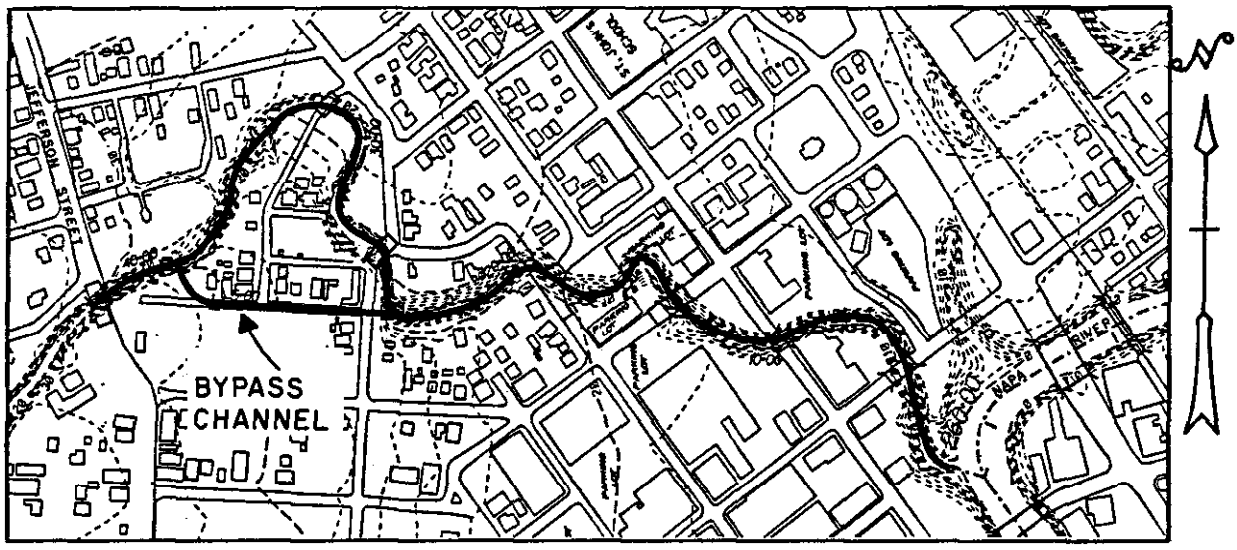

Figure 3. Project reach of Napa Creek showing location of bypass channel.

GEOMORPHIC ANALYSIS

Napa River has been subjected to a number of perturbations that include dredging of a navigation channel, bend cutoff, sand and gravel mining, channel maintenance excavation and significant changes in land use in the watershed. A navigation channel originally was dredged in 1950 and was followed by maintenance dredging in 1962-1963, 1981-1982 and 1988. The upstream limit of the dredging was RM 14.7. Aerial photographs taken in 1958 show that during that time, sand and gravel were removed from Napa River and channel maintenance work that included clearing and snagging of the channel was conducted. Accelerated development of the watershed for grape production has resulted in the use of steeper valley margin lands that have the potential to significantly increase the sediment yield from the watershed. Conservative estimates suggest that development of the hillside vineyards could increase the sediment delivery from these areas to about 59,000 tons/year. Increased sediment delivery from the watershed could increase the need for maintenance dredging both to permit navigation and to maintain flood protection.

Field evidence that includes the presence of: 1) strath terraces, 2) knickzones in the bed of the channel, and 3) exposed bridge footings indicates that Napa River upstream of Oak Knoll bridge is degrading. Field evidence also indicates that some degradation has progressed upstream as far as Zinfandel Avenue bridge (RM 34). Total amounts of recent channel incision range from 4.5 feet to 6 feet. The presence of several knickzones in the channel bed between Oak Knoll Avenue bridge and Zinfandel Avenue bridge suggests that the degradation has been punctuated, and may not be attributed to any single event. Because active channel maintenance practices at numerous locations along Napa River were observed in the 1958 aerial photographs, several small pulses of degradation likely were activated at that time. The cause of the degradation could be channel dredging, sand and gravel mining, channel maintenance, tectonic uplift of the valley, or a combination of all possible factors.

Degradation generally predisposes channels to bank failure and channel widening (Schumm et al., 1984; Harvey and Watson, 1986; Harvey and Schumm, 1987). However, field observation of Napa River indicates that bank erosion is not a serious problem in the study reach. The lack of bank erosion is probably due to the resistance of the bank materials. Bay and marsh sediments, cohesive fan margin sediments and cemented fanglomerates form the lower channel banks and provide considerable stability to the banks. In the multi-channeled reach of Napa River upstream of the project reach (RM 21.5 to RM 23), cohesive bank materials are locally absent, which could provide a significant source of sediment for continued degradation in this area. Base level lowering of Milliken Creek, the result of Napa River degradation, appears to have

accelerated bank erosion along the lower reaches of Milliken Creek as evidenced by the large tributary mouth bar at the confluence. Soda Creek, Dry Creek and Conn Creek have incised in response to base level lowering.

The presence of a tributary mouth bar at the confluence of Napa Creek and Napa River indicates that significant quantities of sediment are being transported by Napa Creek. The size of the sediment in the tributary bar (d_{50} = 3.9 mm) appears smaller than that found in the majority of the bed, which appears to be well-armored. The channel banks of Napa Creek in the project area are almost completely protected.

SEDIMENT TRANSPORT ANALYSIS OF PRE-PROJECT CONDITIONS

An erosion and sedimentation analysis of pre-project conditions was performed to establish the baseline aggradation/degradation trends in the area. The analysis was performed using a sediment continuity model based on joint application of the Meyer-Peter, Mueller (MPM) bed load and Einstein suspended load equations. Armoring calculations were used to establish the limit of degradation potential. Sediment transport in the project reach of Napa River is complicated by tidal backwater, which results in the deposition of fine material (wash load) derived from upstream sources. A separate analysis of fine sediment deposition was performed to supplement the bed material sediment continuity analysis.

The bed material sediment continuity analysis on Napa River showed that aggradation downstream of RM 14.7 is the most significant problem in the project reach. The average annual bed material aggradation volume computed for the reach downstream of RM 14.7, the reach with historical maintenance dredging, was 16,800 cubic yards. The aggradation problem is due largely to the effect of tidal backwater. The project reach upstream of RM 14.7 was shown to be near equilibrium.

To address the deposition of fines not considered in the bed material sediment continuity analysis a relatively simple model was developed based on an algorithm used in the HEC-6 model (COE, 1977). The algorithm determines deposition above a critical shear stress as an exponential decay function of stream velocity and fall velocity of the sediment. The model was calibrated to historical dredge volumes using the fact that approximately half of the material dredged from the project reach is composed of fines. Due to the complexity of fine sediment deposition processes and the fact that the model was calibrated to only one data point (the historical dredge volumes), the use of this model as a predictive tool under project conditions is limited to the determination of direction of change from existing conditions.

The sediment continuity analysis of Napa Creek showed that flooding conditions on Napa River have a significant effect on the computed aggradation/degradation trends downstream of Pearl Street. Under low flooding conditions on Napa River, this section of the project reach showed a significant degradation potential. Under high flooding conditions on Napa River, this same section showed a significant aggradation potential. Napa Creek upstream of Pearl Street is little affected by flooding conditions on Napa River. This section was shown to be slightly degradational to slightly aggradational depending on flow conditions. Field evidence indicates that the bed of Napa Creek in the project is well-armored against degradation. It thus appears that sediment being transported in the project reach is derived from upstream sources with little deposition or scour of the channel bed.

Stable Channel Design Criteria

A large portion of the project area is influenced by tides and the transported sediment contains a large bed material load component, making regime equations inappropriate for use in designing the proposed flood control channels on Napa River and Napa Creek. The designs should be based on goals of maintaining sediment transport equilibrium and ensuring that the channel banks are resistant to erosion. Because aggradation appears to be the biggest potential problem in the project reach of Napa River, either the transport rate needs to be increased or the upstream supply reduced. Tidal influence and the goals of the flood control project may make significant increases in transport capacity impractical. Upstream sediment supply can be reduced by controlling upstream channel degradation and watershed sediment supply. Since the project reach of Napa Creek appears to be relatively stable under project conditions, a major goal of the flood control channel design should be to maintain the existing sediment transport equilibrium. Since an armored channel bed appears to contribute to the reach stability on Napa Creek, the construction

process should minimize disturbances to the channel bed. If this is not possible, it may be necessary to use bed stabilization structures to maintain bed stability. Assuring bank stability under project conditions entails analyzing the erosion resistance of the channel bank sediments and providing bank protection measures where the natural bank sediments are erodible.

SEDIMENT TRANSPORT ANALYSIS OF PROJECT CONDITIONS

The bed material sediment continuity analysis of Napa River under project conditions showed that degradation potential upstream of the proposed cutoff is the most significant problem associated with the proposed flood control plan. Maximum computed degradation depths for this area were equal to 1.3 feet for major storms and 0.7 feet for average annual conditions. The degradation potential upstream of the proposed cutoff results in a significant aggradation potential in the cutoff and bendway. Maximum aggradation computed in this area was equal to 3.1 feet for major storms and 2.1 feet for average annual conditions. Downstream of the proposed cutoff, relatively small aggradation/degradation potential was computed.

The average annual bed material aggradation volume computed for the project reach of Napa River downstream of Third Street (the area of historical dredging activities) was computed as 8,300 cubic yards. This volume is significantly less than the value of 16,800 cubic yards computed for existing conditions. The computed volume for project conditions does not consider the significant aggradation potential computed for the cutoff and bendway. When the aggradation potential in these areas is included, the total volume is equal to 48,000 cubic yards, much greater than that for existing conditions. This result illustrates the need to control degradation in the project reach upstream of the cutoff. Armoring calculations showed that armoring does not appear to limit computed degradation for any case analyzed because the computed degradation depths were less than the computed armor depths.

Using the simple model of the fine sediment settling process calibrated for pre-project conditions, the settling volume for project conditions was computed as 13,900 cubic yards per year. This is approximately 30 percent less than the 19,900 cubic yards per year computed under pre-project conditions, indicating a decrease in deposition problems under project conditions. The results should be used only to indicate a direction of change under project conditions since the fine sediment model is a simple conceptualization of the actual physical processes and has been calibrated to only one data point.

The sediment continuity analysis of Napa Creek under project conditions showed a similar trend as pre-project conditions, with the lower portion of the study reach being affected by flooding conditions on Napa River. Assuming that the armored nature of the existing channel bed will be maintained or the bed stabilized, the analysis was repeated by not allowing the channel bed to degrade. This analysis showed that the project reach of Napa Creek will be in equilibrium under these conditions.

The bed material sediment transport analyses presented in this report assume that the project will not have upstream impacts that would change sediment supply to the project area. It was shown that the only area with a significant potential for upstream impacts is the upstream end of the project reach on Napa River, which also would affect Milliken Creek. Bed stabilization in this area would limit upstream impacts. Although the water surface profile is lowered at the upstream end of Napa Creek, no upstream impacts are anticipated due to the armored nature of the Napa Creek bed.

The bed material sediment transport analysis on Napa River was repeated assuming complete stabilization of the channel bed upstream of the proposed cutoff (RM 15.6). The results showed a significant reduction in the aggradation potential of the cutoff and bendway. The average annual aggradation potential of the project reach including the cutoff and bendway was computed as 22,100 cubic yards, significantly less than the 48,000 cubic yards computed with no upstream stabilization.

A single bed stabilization structure located in the vicinity of Lincoln Avenue would limit upstream degradation caused by the proposed cutoff. An equilibrium slope analysis showed that the average bed slope of 0.0014 for project reach between the cutoff and Lincoln Avenue is much greater than the equilibrium slope of 0.00045. The average bed slope of the project reach upstream of Lincoln Avenue is equal to 0.00047, nearly identical to the average equilibrium slope of 0.00048 computed for this area. Assuming the channel bed

downstream of Lincoln Avenue degrades to the equilibrium slope, a bed stabilization structure located at Lincoln Avenue would be exposed on the downstream end by approximately 2 feet (This figure ignores local scour). Using design charts for a sheet pile bed stabilization structure (Linder, 1963), it was shown that the degradation downstream of the structure would have only minor effects upstream.

CONCLUSIONS

The following conclusions can be drawn from the Phase I investigation:

1) Upstream of the project reach (RM 6 to RM 17.3), Napa River is presently degrading.

2) The cause of the degradation is unknown, but it could be due to at least four factors: a) dredging of the navigation channel, b) sand and gravel mining, c) channel clearing and excavation, d) tectonic uplift or any combination of the four factors.

3) Degradation of Napa River has lowered base level for its tributaries. Milliken Creek, Dry Creek, Conn Creek and Soda Creek have responded by degrading.

4) Field evidence and air photo analysis indicate that some degradation has progressed as far upstream as Zinfandel Avenue bridge (RM 34).

5) The resistance of the channel perimeter sediments along the degraded reach has prevented the occurrence of severe bank erosion as a result of channel degradation.

6) Erosion-resistant sediments are locally absent upstream of the project reach of Napa River. Continued channel degradation, therefore, may cause localized channel erosion and result in the delivery of significant quantities of sediment to the project reach.

7) Napa Creek within the project area appears to be stable with an armored channel bed and mostly protected channel banks.

The following conclusions can be drawn from the Phase II investigation:

1) The project reach of Napa River has significant aggradation problems under pre-project conditions as manifested by the need for maintenance dredging of the navigation channel. These problems are the result of upstream channel degradation and high watershed sediment yield.

2) The need for maintenance dredging is likely to continue under project conditions unless upstream sediment supply is reduced significantly. This supply can be reduced either by controlling upstream channel degradation through the use of bed stabilization structures or by controlling watershed sediment yield or both.

3) Sediment being transported in the project reach of Napa Creek is derived from upstream sources with little deposition or scour of the channel bed.

The following conclusions can be drawn from the Phase III investigation:

1) The most significant aggradation/degradation related problem for the project reach of Napa River under project conditions is a significant degradation potential upstream of the cutoff (RM 15.6). This degradation results in a significant aggradation problem downstream.

2) The project reach of Napa Creek appears to be stable under project conditions, assuming the armored nature of the channel bed is maintained or adequate bed stabilization measures are implemented.

3) Stabilization of the project reach of Napa River upstream of the cutoff will reduce downstream aggradation problems significantly. Stabilization of this reach also will mitigate upstream impacts.

4) A single bed stabilization structure located upstream of the proposed cutoff would provide adequate stabilization of the upstream reach. The structure could be installed at-grade using grouted or ungrouted rock, sheet piling or a concrete sill.

ACKNOWLEDGEMENTS

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HYDRAULIC CHANGES IN RIVERS DUE TO NAVIGATION

By Nani G. Bhowmik, Principal Scientist, Illinois State Water Survey, Champaign, Illinois.

ABSTRACT

Movement of river traffic such as tows, barges, or recreational craft in navigable rivers and streams can temporarily alter the hydraulic characteristics of the river cross section. These changes may include bow, stern, or transverse waves; resuspension of bed sediments; changes in velocity structures either in close proximity to the moving vessel or within the water body; altered flow direction; and transport of sediment and water into side channels, sloughs, or backwater lakes. Research is being conducted at the Illinois State Water Survey to determine and evaluate the changes that may accompany the movement of river traffic within the Upper Mississippi River System (UMRS). The UMRS extends from Cairo, Illinois, at the junction of the Mississippi River with the Ohio River, to the headwaters of the Mississippi River in Minnesota. The major tributary of this system is the Illinois River.

Data were collected on waves, drawdown, sediment, and velocities by using state-of-the-art equipment and instrumentation. Analysis of the data has shown that barge traffic can temporarily increase the concentrations of suspended sediments; that it will alter the two components of the velocities, the magnitudes of which are dependent upon the relative distances of the measuring points; and that it can generate waves and drawdown. The duration of the increases in suspended sediment concentrations and velocities is dependent on the traffic characteristics and ambient flow conditions of the river. It was also observed that flows near the shore zone can change direction as a result of the movement of loaded or unloaded barges.

Physical changes associated with the river traffic may alter some biological habitats. Research on physical changes resulting from river traffic is geared toward determining the relative importance of alterations in the river environment and how they may affect the aquatic habitats.

INTRODUCTION

This paper briefly describes some of the analyses performed on the physical changes associated with river traffic on the Illinois River. The analyses dealt primarily with increases in suspended sediment concentrations after the passage of barge tows at a section of the Illinois River. Analyses are also presented on the changes in velocity structures near the shore zone as the barges passed the site. The maximum configuration of a barge tow convoy on the Illinois River is three barges wide and five barges long. Barges are 59.5 m long and 10.7 m wide. Each tow is about 30.5 m long. Fully loaded barges have a draft of 2.74 m. Thus a fully loaded 3 by 5 barge convoy will occupy a volume of water about 328 m by 32.1 m by 2.74 m. Normally barges move at a speed of about 1.3 to 4 m/s. In many instances a tow will push either a single barge or multiple barges which may or may not be fully loaded. An unloaded barge normally displaces about 0.61 m of water.

Movement of such a large body through a river channel such as the Illinois River can temporarily change the flow pattern, with an associated increase in suspended sediment concentrations. At many locations, the Illinois River is about 250 to 275 m wide with an average depth of 3.6 to 4.5 m. Thus a fully loaded 3 by 5 barge convoy can occupy as much as 9 to 10 percent of the cross-sectional area at any time.

BACKGROUND

The general nature of the flow field around a barge tow or other vessel is dependent upon the river cross section, water depth, draft of the barge, and speed and direction of movement. For a typical barge-tow convoy, the flow field near the barges changes, and at the same time flow is accelerated below the main body of the barge. The amount of acceleration will be greatest when the water is shallow relative to the draft of the barges.

The physical impacts of the movement of barge tows on the riverine environment are given by Bhowmik and Mazumder (1990) and include velocity and pressure fields of flow around the vessel and through its propulsion propellers, surge, drawdown, and waves caused by the displacement of river flow by the vessel, surface waves, and resuspension and movement of sediment. The magnitude of each effect depends on the size, geometry, direction, and speed of the vessel; the size and shape of the channel, and the position of the vessel track within the channel; and the characteristics of the river bed materials and suspended sediment particles.

The Illinois State Water Survey (ISWS) was involved in the Master Plan studies of navigation impacts for the Upper Mississippi River System. Though these studies were truncated in scope, valuable information was obtained and reported to the UMRBC (Bhowmik et al., 1981a, 1981b, 1981c, 1981d, 1982). These studies showed that barge traffic can temporarily increase suspended sediment concentrations and create waves and drawdown. The magnitude and duration of increased sediment concentration, waves, and drawdown depend on the physical and dynamic characteristics of the waterway and the barges.

Research on changes in suspended sediment concentrations and turbidity resulting from navigation was conducted by Johnson (1976) on the Illinois and Mississippi Rivers. He measured dissolved oxygen and collected water samples for suspended sediments following passage of commercial vessels in upper, middle, and lower reaches of the Illinois and Upper Mississippi Rivers. Johnson's work showed that the tows did not increase the suspended sediment concentrations above those present during flood stages on the Upper Mississippi River. In the Illinois River, some additive effect on the increase in suspended sediment concentrations was observed.

ISWS researchers are now conducting an investigation on the changes in velocity, turbulence, drawdown, waves, and suspended sediment concentrations associated with the movement of barge traffic in a few selected reaches of the Mississippi and Illinois Rivers. This investigation has been initiated as part of the environmental monitoring of the Upper Mississippi River System associated with the construction of the Melvin Price Lock and Dam (second lock) on the Mississippi River near Alton, Illinois. Field data are being

collected, and a very preliminary analysis of some of those data on suspended sediment concentrations and velocity changes are described in this paper.

DATA COLLECTION

The present project by the ISWS was initiated in late 1988, and data were collected from the Illinois River in 1988 and 1989. Additional data from the Mississippi River were collected in May 1990, and several more field trips will be made during 1990 and subsequent years. During this time, data on physical changes due to navigation traffic will be collected. The data presented in this article were collected from the Illinois River at River Mile 50.1 near McEvers Island. The channel at this location is 290 m wide and about 4 to 5 m deep. Data on changes in suspended sediment concentrations and velocities were collected from this site.

The suspended sediment samples were collected from either two or three intakes at each of three different locations. The water and sediment samples were pumped by vinyl tubing with DH-48 nozzles attached at the end of the tubes. All the samples were pumped to a shore station where standard suspended sediment sampling bottles were filled. The sediment intake structures were located in a line perpendicular to the shore and at distances of 14, 18, and 24 m from the shore. All the nozzles were pointed upstream. The intakes were located 0.15 and 0.6 m above the bed at Station 1 (14 m from the shore), 0.15, 0.6 and 1.2 m above the bed at Station 2 (18 m from the shore); and 0.15, 0.6, and 1.8 m above the bed at Station 3 (24 m from the shore). Background samples were collected at 20-minute intervals and the event sampling frequency varied from 2- to 3-minute intervals. Descriptions of these sampling techniques are given by Adams and Delisio (1990).

The velocity data were collected at four locations by using two-dimensional current meters. The current meters used were two S4 interoceanic velocity meters, one Marsh-McBirney 527 current meter, and four Marsh-McBirney 511 meters. Three MM511s were installed on a vertical array to gather data on the vertical distribution and variability of the altered velocity changes. Velocity data were collected at 1-second intervals from all the meters at all times.

ANALYSES OF DATA

The analyses of the data performed for three events for both the suspended sediment and velocity changes are briefly described here. The data presented here are confined to the set of data collected during the week of May 16-19, 1989.

Suspended Sediment

During the above-mentioned period, 1,700 suspended sediment samples for 10 tow passage events were collected (Adams and Delisio, 1990). The draft-to-depth ratio for this section of the river was 1.66 for a 2.74 m draft (fully loaded) and 5.96 for a 0.75 m draft (unloaded). The blocking factor, defined as the inverse of the ratio of submerged vessel cross-sectional

area to channel area, ranged from about 90 for one empty barge to about 8.6 for a three-wide loaded barge for this location.

The variability in suspended sediment concentrations during a tow passage event is illustrated in figure 1. The example chosen is for the tow boat Mobil Leader, which has twin screws, 5,000 horsepower (3,725 kw), and ducted or Kort nozzle propellers. It was pushing six-wide loaded barge with a 2.74 m draft in the upstream direction at a speed of 3.62 m/s. The barge was sailing about 122 m from the shore. The three parts of this figure illustrate the changes in suspended sediment concentrations at the three stations and also at two to three different elevations.

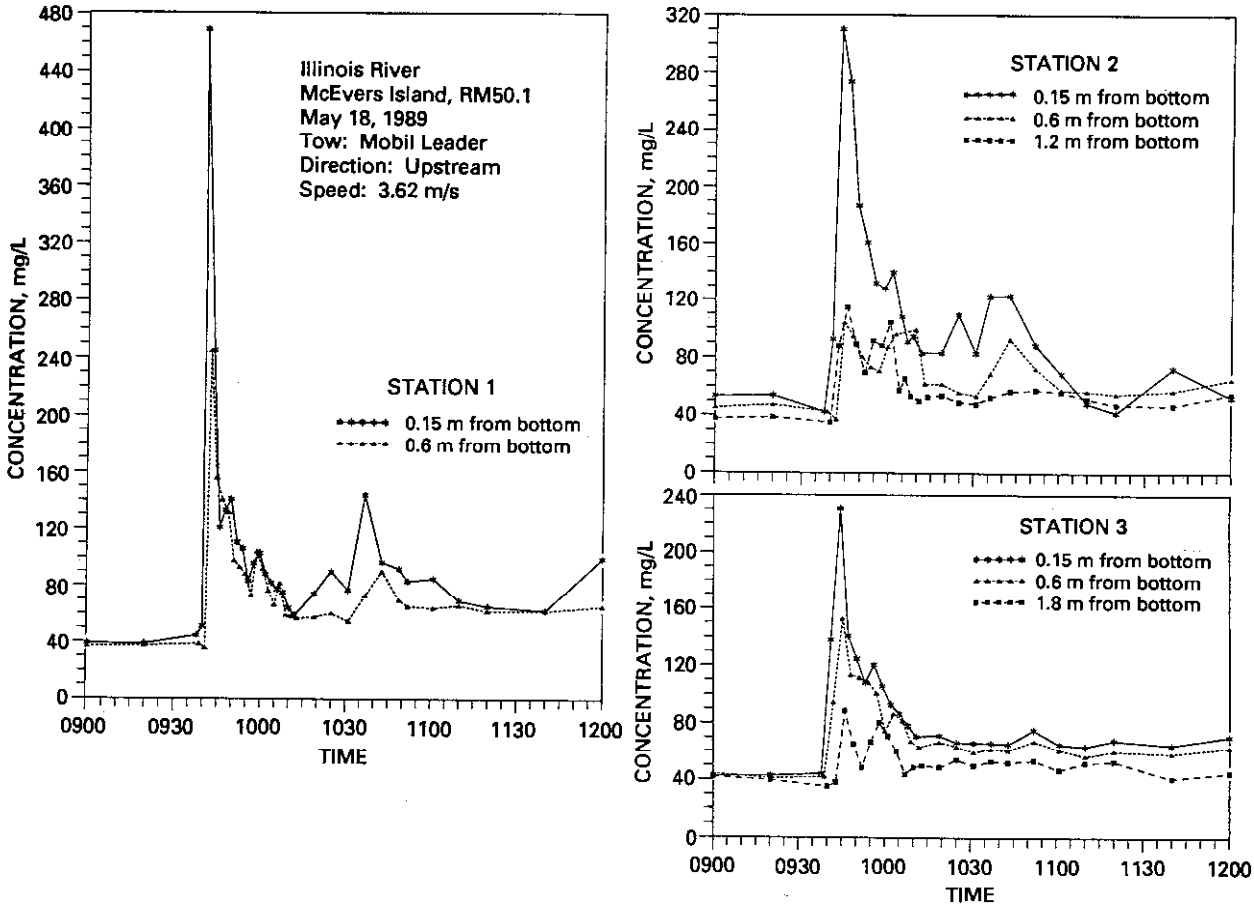

Figure 1. Variability in suspended sediment concentration due to the movement of a barge tow

For Station 1, located 14 m from the shore, the maximum increased suspended sediment concentration at the 0.15 m elevation above the bed is about 10 to 12 times more than the ambient sediment concentration. Similarly, at the 0.6 m elevation at the same location, the increased concentration is about 6 to 7 times more than the ambient concentration. When these increases are compared with the increases at the other two stations — Station 2 (18 m from the shore) and Station 3 (24 m from the shore) — it will be found that these increases are smaller than those observed at Station 1. However, in all cases, there is a

distinct trend in that the increase in suspended sediment concentration near the bed at the 0.15 m elevation is always greater than those observed at the 0.6 m, 1.2 m, or 1.8 m elevations. As a matter of fact, there is a vertical gradient at all the stations, where the increase in concentration is greatest near the bed with a gradual decrease toward the surface. It should be pointed out here that the top intake at all locations was about 0.75 m below the water surface.

Data collected from other barge events also showed similar variability. It should also be mentioned that these data were in the near-shore zone, where the bed material is composed of 40 percent sand, 40 percent silt, and 20 percent clay.

Velocity Data

A substantial amount of velocity data were also collected for this project. Only two sets of data for a single component of velocity are described in this paper. These data were collected from the same site and at the same time as the sediment data. Figure 2 shows the net velocity changes at different locations for two events. For one event the tow was moving in the upstream direction, and for the other event the tow was moving in the downstream direction. Both the tows were moving at or near the sailing line, which was about 122 m from the shoreline. Since the velocity data were collected continuously throughout the whole day, it was quite easy to determine an ambient velocity at the sampling point both before and after the passage of the tow. These ambient velocities were then subtracted from the increased velocities to determine the net changes in velocities. These values are shown in figure 2. The component of the velocity shown in then figure is the one parallel to the direction of the main flow. Even thrugh all the meters are not located at the same elevations at all the stations, comparisons can be made about the changes in velocities at various locations for the same event and also for the same time interval.

When a tow Reliance with 15 barges moves upstream with an effective draft of 2.1 m and a speed of 2.63 m/s (figure 2a), the net increase in velocity at 10.6 m from the shore is higher than increases observed at distances of 15.3, 36.6, and 45.8 m from the shore. Moreover, increases at the 0.15 m elevation above the bed at distances 10.6 and 36.6 m from the shore are higher than those observed at the 0.92 m elevation above the bed at distances of 15.3 and 45.8 m from the shore. As the barge moves upstream, it pushes water in front of it with an associated return flow in the downstream direction on both sides of the barge. This is exactly what was observed for this case, where the net increase in flow velocity was as much as 0.4 m/s and the increase lasted for about 3 minutes. This figure also illustrates the lag in time between the maximum increases in velocities at various locations. The increased velocity was initially felt close to the shore before it was felt at other locations away from the shoreline.

The illustration in figure 2b shows the changes in velocities at three different locations when the tow Illini, pushing 11 fully loaded barges, was moving in the downstream direction with a speed of 1.95 m/s. Again, the velocity changes shown are the net velocity changes obtained by subtracting the ambient velocity from the measured velocities during this event.

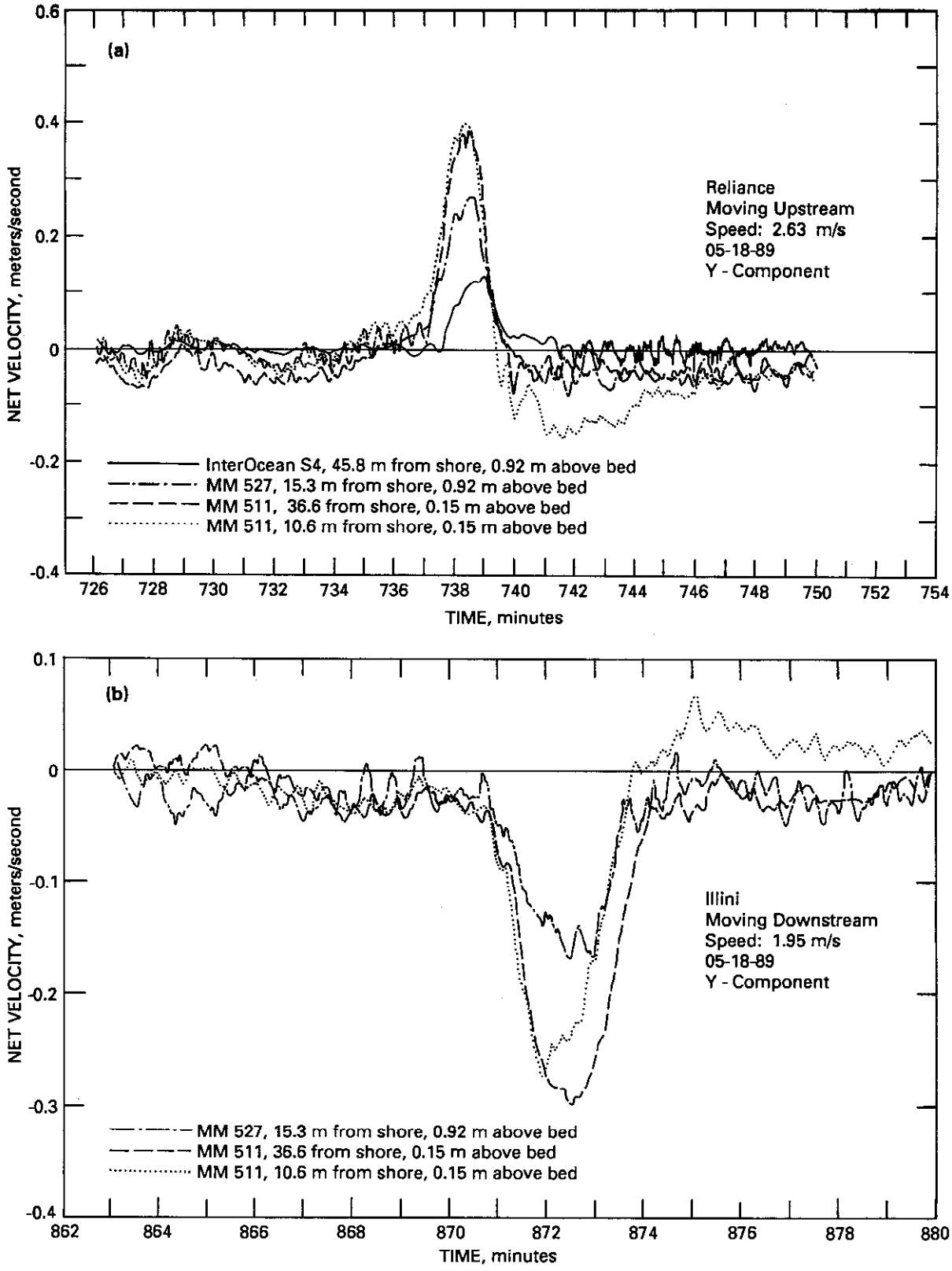

Figure 2. Net velocity changes due to barge movement

It is quite clear that the movement of this barge-tow configuration in the downstream direction generated return flows in the upstream direction on both sides of the barges between the barges and the shoreline. This return flow was strong enough to temporarily alter the direction of flow at all three locations for about 3 minutes. Again, for this case also, the maximum increase in return velocities was observed at the 0.15 m elevation above the bed at distances of 10.6 m and 36.6 m from the shore. The increase in velocity at the 0.92 m elevation above the bed at a distance 15.3 m from the shore was smaller than those observed at the other two stations. This figure also illustrates the fact that the changes in velocities are higher near the bed than away from the bed. The return flow was as much as 0.3 m/s and lasted for about 3 minutes.

Velocity data collected from other barge events also showed similar variabilities. The other components of velocity perpendicular to the main flow showed that the return flow does not move parallel to the shoreline, that the pattern of altered velocity regime is quite complex, and that the resultant velocity should be considered in any further analyses even though the component of the velocity parallel to the shoreline is normally considered in one-dimensional modeling efforts.

SUMMARY

This paper has briefly described the changes associated with the movement of barge traffic within a restricted waterway such as the Illinois River. For such a river having a sand, silt, and clay bed, fully loaded barge traffic can temporarily increase the suspended sediment concentrations, especially near the channel border areas. These increases are greater near the bed than in the near-surface zone, and they can last from about 40 to 60 minutes or more. Similarly, movement of the barges can alter the velocity regime, with the maximum changes occurring near the bed. Upstream movement of traffic can increase the downstream velocity component between the barge and the shoreline. At the same time, barges moving downstream can temporarily reverse the flow in the upstream direction between the barges and the shoreline. In all these cases, the maximum increases in velocities were observed to occur very close to the bed.

ACKNOWLEDGMENTS

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SEDIMENT RETARDATION AT URBAN DEVELOPMENT SITES

By Rick Morse, Urban Soil Conservationist, and Geoff McVey, Civil Engineer, Morse McVey & Associates, PO Box 138, Picton NSW 2571, AUSTRALIA.

ABSTRACT

Many government planning and/or control agencies in Australia, are now strongly recommending the preparation of soil and water management plans as a condition of development consent on urban lands. One element of such plans includes delineation of structures to minimise sediment pollution to downslope lands and waterways, particularly during any nominated development.

This paper reviews some of the methods and techniques currently employed in sediment control, especially on larger subdivisions in New South Wales (NSW). In particular, design criteria are discussed in terms of: addressing the volume of soil materials available for sediment pollution, providing for adequate settling time, and ensuring appropriate stability of structures.

INTRODUCTION

Most land degradation associated with urban development in NSW results from high rates of erosion by water and consequent sediment pollution to downslope lands and waterways. Other pollutants are often associated with the sediment, including nutrients, pesticides and other contaminants (Lake Illawarra Management Committee, 1985).

In the past, the high rates of erosion have resulted from inappropriate development of urban lands through lack of a soil conservation ethic by many planners. Such planners have often regarded economic viability as the principle constraint to development and have had minimal consideration for long term environmental protection.

Further, soil conservation advice at the government level has been restricted largely, to providing urban capability information to only a small number of planners (Junor, 1989) with very little assistance being given to those required to implement soil conservation works on the ground. This has been because the Soil Conservation Service of NSW has committed very limited staff resources to urban matters.

The problem seems to have increased markedly in recent years, particularly as the more "marginal" lands are developed around the principal urban centres of Sydney, Newcastle and Wollongong (figure 1).

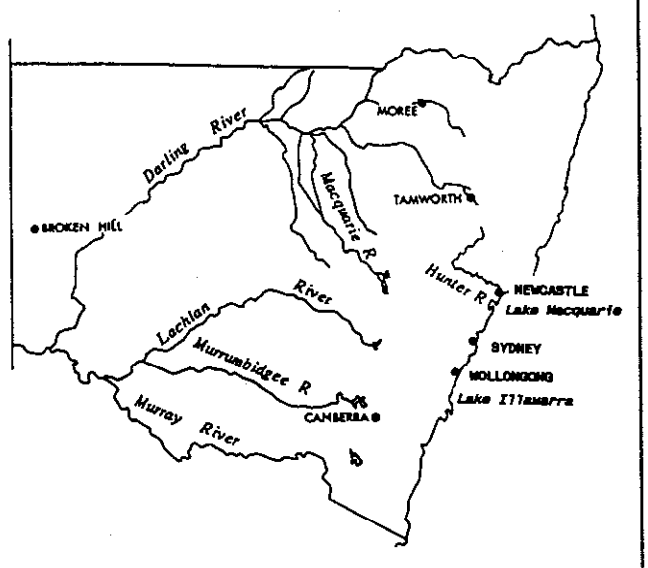

Fig. 1. New South Wales, Australia.

However, in recent years, the general community has become far more aware of environmental needs. This awareness has placed considerable pressure on government to the extent that in the last election in the State of Tasmania, the sitting government lost power principally on environmental issues (Dodd & Massey, 1989). Further, many would argue that the party which won the recent Federal elections, won by default, with a major reason being that key opposition parties did not present acceptable environmental platforms - it suffered a 6.6 percent swing, gaining only 39.7 percent of the primary vote. Effects such as these have promoted an environmental awakening of our leaders, with many labelling themselves as "greenies" (Austin, 1990).

Accordingly, environmental issues are now concerns of high priority and have resulted in the NSW Government adopting the principles of Total Catchment Management (TCM) (Cunningham, 1986) which aims, among other things, to ensure that any development is sustainable[1].

In addition, the Soil Conservation Service of NSW is currently upgrading its text on erosion and sediment control in urban areas (Hunt, in prep) while the Department of Housing is preparing a "cook book" (Dept. Housing, in prep) on soil and water management for use by all contractors on development sites under their control. The latter handbook is likely to be adopted by many other consent authorities in the Sydney, Newcastle and Wollongong regions. Further, the Lake Illawarra TCM Committee, comprising members of State and Local Government authorities, has prepared a set of draft guidelines on soil and water management for urban development sites (TCM Committee of Lake Illawarra, 1989) and has been adopted by three local government authorities.

The preparation of these documents has prompted considerable debate on techniques for soil and water management likely to be applied in the near future during urban development in NSW. This paper reviews some of the techniques relating to sediment retardation being considered by the Department of Housing and reflects the requirements of the Soil Conservation Service of NSW (Quilty, Hunt & Hicks, 1978) and the State Pollution Control Commission (SPCC, 1989).

SEDIMENT RETARDATION CRITERIA

General Criteria

1. Any sediment laden stormwater runoff should be filtered through a trap or retarding basin designed to minimise pollution to lands, waterways and services located further downslope on all sites where soil and water management plans are required with development proposals. These sites occur generally, where the disturbed area exceeds that shown in Table 1.

2. Sediment trapping or retarding devices should be located to keep sediment as close to source as possible, and upstream of nutrient removal ponds.

3. Sediment control measures should be installed before the construction program commences and be maintained in an effective condition until all earthwork activities are completed and the site rehabilitated.

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1 The Brundtland Report (1987) describes "sustainable development" as development that meets the needs of present generations without compromising the likely needs of future generations.

TABLE 1
Threshold area for need for soil and water management plans.

Physical Limitations to Development	Slope Gradient Class	Area of Disturbed Lands
Low[2]	less than 10 percent above 10 percent	5 000 square metres 1 500 square metres
Moderate[3]	all classes	300 square metres
High[4]	all classes	100 square metres

4. Trash racks should be constructed upstream of permanent retarding basins and wetlands which have a capacity greater than 500 m^3 [17 660 ft^3], and elsewhere as required by officers of the Department of Housing.

5. Other drainage works, particularly those affecting possible erosion of soil and consequent pollution of trash and sediment, should be installed as a first step in the construction program to convey stormwater safely through, and away from, the site.

Design Criteria

With the design criteria below, sediment basins and sediment traps[5] are categorised into one of two groups:

(a) *Type C* - includes all sediment traps and those sediment basins (preferably dry) on lands where more than one third of the subsoil particles have a diameter greater than 0.02 millimetres; and

(b) *Type F* - includes only those sediment basins (always wet) on lands where less than one third of the subsoil particles have a diameter greater than 0.02 millimetres.

The design criteria are as follows.

1. Where possible, only sediment laden run-off water should enter sediment basins and sediment traps.

2. Sediment basins and sediment traps should have -

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2 Limitations can be overcome using standard engineering and site management techniques.

3 Generally, limitations can be overcome only with specialised engineering and site management techniques. May contain undifferentiated pockets of land where standard methods apply.

4 The limitations on these lands can overcome using specialised, site specific engineering and management methods only.

5 Not including sediment barriers which may be placed at stormwater inlets.

(a) capacities greater than -

(i) *Type C* basins and traps -

* the maximum volume of water that will enter in six minutes in a $Q_{5,1hr}$ storm event, and

* that indicated by the USLE and indicating the volume of subsoil materials likely to enter over one year when the vegetative cover and topsoil are removed, or

(ii) *Type F* basins - the maximum volume of water that will enter in twelve minutes in a $Q_{5,1hr}$ storm event;

(b) storage depth, including both settling and sediment zones, of at least one metre [40 inches] in either basin type (does not relate to traps);

(c) internal dimensions in either basin type (does not relate to traps) which provides -

* maximum distance from the inlet to the outlet and at least twice the width, and

* maximum surface area;

(d) an outlet of sufficient width so that water does not exceed 10 centimetres [4 inches] depth during a $Q_{5,1hr}$ storm event;

(e) a wall and spillway/outlet designed to withstand at least the erosive forces from the $Q_{20,tc}$ storm event. In some situations, particularly where failure is likely to result in severe degradation, substantial loss of property or be a potential danger to human life, it may be necessary to design for stability in a higher year storm event.

3. Sediment control structures should be maintained such that:

(i) *Type C* basins have -

* sediment removed when 40 percent of their capacity is lost to pollution, and

* a minimum settling zone depth of at least 0.5 metres [20 inches] over 80 percent of the structure's surface area;

(ii) *Type C* traps have -

* sediment removed when 40 percent of their capacity is lost to pollution, and

* any straw materials replaced within 6 months and geofabric materials replaced within 12 months;

(iii) *Type F* basins -

* are treated with gypsum (320 mg/L) whenever capacity is reduced by more than 20 percent by water and sediment, and drainage commenced 36 to 48 hours later, and

* have sediment removed when 10 percent of capacity is lost to pollution.

Any waste material should be disposed in sediment dumps where further pollution to downslope lands and waterways is unlikely.

CONSTRUCTION TECHNIQUES

NSW contractors are rarely given instructions on the methods to be used for construction of sediment basins or traps, providing they meet the relevant design criteria. However, options may be suggested. Some of these options are included in the comments below.

Dewatering Dry Sediment Basins

Techniques for dewatering dry sediment basins commonly involve the use of geofabric. The use of sand or gravel as a filtering medium is not encouraged because it is more difficult to maintain. Geofabric is usually placed:

(i) on the inside of gabions,

(ii) on 50 to 75 millimetre [2 to 3 inch] aggregate (maximum batter gradient 1.5(H):1(V)) placed on the inside of a wall constructed from local rock materials, or

(iii) around a perforated riser structure held in place with a light wire mesh.

Which ever method is used, the geofabric should be replaced each alternate time sediment is removed from the basin to minimise the likelihood of the pores blocking and becoming essentially a wet basin.

Design of Sediment Traps

The same design criteria as above should be used for sediment traps[6], however, calculations are not usually presented in the soil and water management plan for more than about one structure in five. Sufficient information is presented to ensure that, generally, they will achieve their task of mitigating sediment pollution up to the $Q_{5,1hr}$ storm event and not failing before the $Q_{20,tc}$ storm event.

Accordingly, straw bale dykes and "silt" fences should rarely be placed along the contour, because water will invariably run to a low point in large storm

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6 Sediment traps differ from sediment basins in that they are very easy and, generally, inexpensive to construct. Materials used include straw bales, geofabric attached to wire fences, geofabric over straw bales, earth berms, etc.

events and the structure will fail. Rather, they should be placed with small returns at about five to thirty metres, creating a series of small sediment traps in line. The catchment area of each trap should be small enough so that $Q_{20,tc}$ does not exceed 25 litres [4 gallons] per second. This system has the added benefit of avoiding concentrated flows.

Gabion Baskets in Wet Sediment Basins

Gabion baskets are occasionally suggested for use in the walls of basins where a dry basin is required during the construction phase to trap sediment, and an artificial wetlands required once the residential phase is well established to trap nutrient pollutants. Figure 2 is taken from a soil and water management plan for urban development on a site north of Sydney (Gutteridge, Haskins & Davey, 1988) and shows a diagrammatic cross section of part of a proposed artificial wetlands, where:

Total Catchment Area = 3.20 ha [7.9 ac]
Average Annual rainfall = 1 070 mm [42 in]
Q_{20tc} = 1.64 m^3 [58 ft^3]/sec (t_c = 5 min)
$Q_{5,1hr}$ = 0.30 m^3 [10.6 ft^3]/sec
Disturbed catchment area = 0.70 ha [1.72 ac]

Full storage capacity (USLE) = 250 m^3 [8 830 ft^3]/$ha_{disturbed}$
= 175 m^3 [6 180 ft^3]

Full storage capacity for 6 min, $Q_{5,1hr}$ = 108 m^3 [3 810 ft^3]

Full storage capacity for wetlands = 328 m^3 [11 580 ft^3] (3.83% average annual runoff - Hartigan, 1986)

Actual Design Capacity = 484 m^3 [17 100 ft^3]

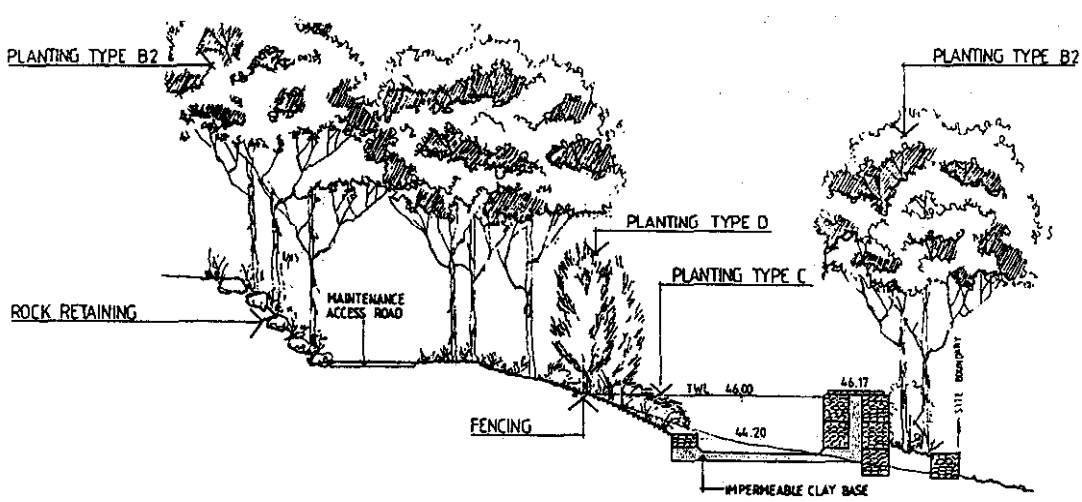

Fig. 2. Nutrient retarding basin.

During the "dry" phase, only the outer layer of gabions are installed and lined on the upstream side with geofabric.

Sediment Basins, First Flush and Wetland Design

A number of options have been suggested in the literature to mitigate sediment and nutrient pollution (Maryland Department of Natural Resources, 1987; Livingston, E.H., *et al,* 1988; Gutteridge, Haskins & Davey Pty Ltd, 1989). The example, below (figure 3) is to be constructed in Picton, NSW (Morse McVey & Associates, 1990) and is somewhat different. It is designed to:

(i) trap most sediment particles coarser than 0.02 mm,

(ii) take all trickle flows and the first flush (based on the first 10 millimetres [0.4 inches] of runoff),

(iii) ensure stability of the wetlands in large storm events.

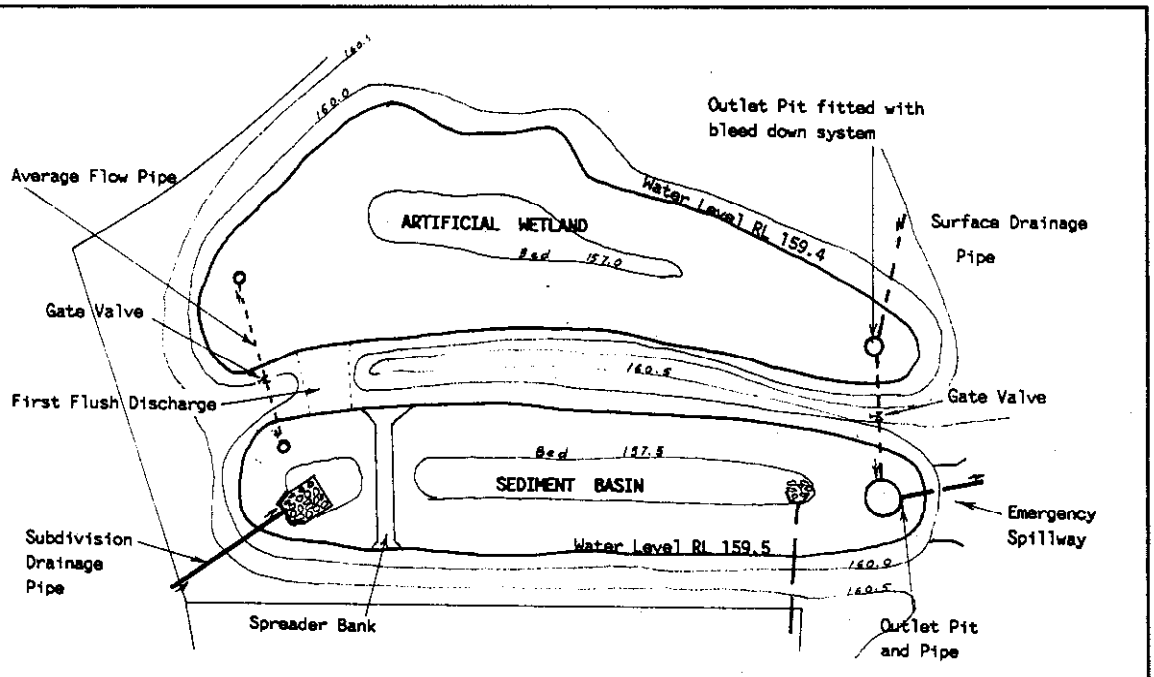

Fig. 3. Combined sediment and nutrient retardation basins.

Basic design is based on similar principles to those given for figure 2. Additional criteria are in this instance are:

(a) The total design capacity of the <u>sediment basin</u> is 920 m^3 [32 500 ft^3] (of which 620 m^3 [21 900 ft^3] are permanent and 300 m^3 [10 600 ft^3] are temporary). The reduced level of the first flush discharge spillway is midway between the average flow pipe (25 percent of $Q_{1,24hr}$) and the system outlet.

(b) The total design capacity of the <u>artificial wetland</u> is 1 350 m^3 [47 680 ft^3] (3.83% of average annual runoff - 950 m^3 [33 550 ft^3] are permanent and 400 m^3 [14 130 ft^3] are temporary). The outlet is a V-Notch weir designed initially to discharge the temporary storage over 5 days, and, when temporary capacity is reached, to discharge at 25 percent of $Q_{1,24hr}$.

CONCLUSIONS

Protection of the environment has become a priority matter with government authorities in NSW since the mid 1980s. Part of this issue is the evolution of the need for soil and water planning as conditions of development consent in urban areas, and mitigation of sediment pollution is an essential component of such plans. While a number of innovative systems are being installed, techniques for sediment control are still very much in their infancy.

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LANDSLIDE RESPONSE TO TIMBER HARVEST IN SOUTHEAST ALASKA

by Douglas N. Swanston, Principal Geologist, USDA Forest Service Pacific Northwest Research Station, Juneau, Alaska and Daniel A. Marion, Research Hydrologist, USDA Forest Service Southern Forest Experiment Station, Oxford, Mississippi.

ABSTRACT

Forest harvest operations in southeast Alaska have influenced both frequency and size of landslide events. The landslide occurrence rate in undisturbed areas over the 21-year period 1963-83 is $1.5x^{-3}$ landslides/km^2/yr. The occurrence rate in harvest areas over this same time period is $5.3x10^{-3}$ landslides/km^2/yr., 3.5 times greater. As a general rule, landslides in harvest areas are significantly smaller, occur at lower elevations, develop on gentler gradients, and tend to travel shorter distances.

INTRODUCTION

Southeast Alaska is characterized by naturally steep slopes, shallow soils, and a thick, old-growth forest cover of western Hemlock and Sitka spruce. Climate is maritime--cool and moist--with abundant rainfall distributed throughout the year. Precipitation ranges from 1524 and 5080 mm a year with maximum accumulations in the fall (September, October, November) associated with storms crossing the north Pacific. Because of high soil permeabilities, slope drainage is primarily by subsurface flow with little or no overland flow outside established channels. When overland flow does occur, the thick mat of forest vegetation is adequate to protect the mineral soil from surface erosion. During major storm periods, high soil moisture levels and local areas of saturation are produced on slopes, greatly increasing the unstable character of the surfacial materials. Under these conditions, soil mass movements (landslides) are a dominant process of soil erosion and sediment transport from steep mountain slopes to the valley floor and adjacent stream channels. This paper presents the initial results of research into how landslides in southeast Alaska are affected by timber harvesting. The research differs from past work in that we assess landslide occurrence over a much larger area (over 42,000 km^2) and evaluate a time period (1963-1983) during which the vast majority of timber harvesting in Southeast Alaska has occurred.

LANDSLIDES IN THE UNDISTURBED ENVIRONMENT

In the early 1960's, prior to large scale harvest activities, unpublished aerial photographic studies (Helmers[1]) documented the occurrence of 1374 failures greater than 77 m^3 (100 yd^3) in initial failure volume at forested sites scattered over the Tongass National Forest south of the 59th Parallel (Figure 1). Failure sites older then 50 years, which were generally revegetated with alder and spruce, were not counted. Smaller failures abounded, but were not consistently identifiable beneath old-growth forest cover at the aerial photographic scales available (1:12000 to 1:15840), and were also excluded from the tallies. Within the limits of this sample, most failures occurred in unique topographic situations and appeared to be directly linked to initiation by temporary water table development during high intensity storms (Swanston, 1969). That mass erosion has been a continuing process over much of the Holocene is demonstrated by the common occurrence of talus cones with buried and overturned soil profiles along the toe or foot-slopes of most stream valleys, and widespread occurrence of shallow linear depressions and headwall scarps on middle and upper slope sites.

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[1]Austin E. Helmers. Unpublished data on file at USDA Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory Box 20909, Juneau, Alaska 99802.

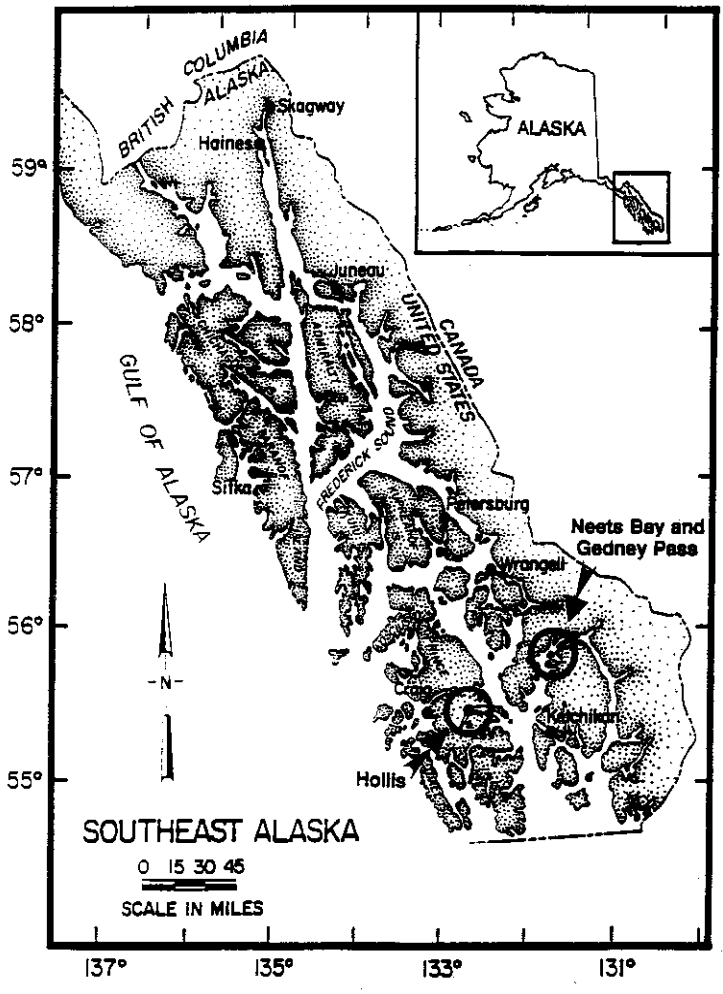

Figure 1-Planimetric map of southeast Alaska showing location of major study areas.

Of the natural (undisturbed) failures identified in this early survey, 87% were of the debris avalanche/debris flow type (Varnes, 1978) developed on open slopes or interfluves unassociated with active stream courses. Almost all of these failures originated as debris avalanches in shallow, linear depressions oriented perpendicular to the slope contour in which convergent ground water flows and associated pre-historic landslides had occurred. Released material, a mixture of rock, soil, organic debris, and entrained water was generally carried to the base of the slope as a debris flow. On reaching the toe-slope or valley floor, deposition occurred rapidly due to reduced gradients and the buttressing of intervening trees. Only about 15% of these debris flows reached perennial streams directly, because of the characteristically broad, flattened valley floors. The remaining 13% of natural failures were debris torrents (also called debris floods) (Varnes, 1978) resulting from rapid deposition of large volumes of material released from adjacent slopes into confining gullies and canyons during periods of storm flow. While the number of such failures was small, more than 34% of the debris torrents cataloged reached low gradient stream sections and caused clearly identifiable changes in channel morphology. Such changes included alterations in channel flow path, riparian area destruction adjacent to the active channel, channel aggradation, and movement and redistribution of large woody debris.

CONTROLLING CHARACTERISTICS AND MANAGEMENT EFFECTS

An early analysis of post-logging landslide activity at Hollis on Prince of Wales Island, and at Neets Bay and Gedney Pass on Revillagigedo Island (Bishop and Stevens, 1962) (Figure 1) documented an acceleration rate 4 times the natural rate following the first clearcut harvesting on a major scale in southeast Alaska. Roads were restricted to stable locations on lower slopes and the valley floor in these areas so that road impacts did not enter into the analysis. Later work has identified controlling climatic, materials, and terrain characteristics and has linked increased landslide activity to alterations in ground water/surface water flow regimes and the destruction of stabilizing root systems due to timber harvest (Swanston, 1967, 1969, 1970, 1972; Wu et. al., 1979; Wu and Swanston, 1980; Sidle, 1984, 1985; Sidle and Swanston, 1982). Prominent among these controlling characteristics are:

* the occurrence of high rainfall intensity and duration zones due to the orographic effects of steep mountain slopes and controlled circulation of major storm cells by valley lineaments;

* exceptional slope steepness and the presence of structural gullies and shallow linear depressions (old landslide tracks) which increase gravitational stresses, foster subsurface water convergence, and increase potential runout length;

* strongly glaciated bedrock surfaces with an intermittent veneer of glacial till and colluvial debris, which control landslide location and type, and the strength or resistance of overburden to failure.

INFLUENCE OF TERRAIN CHARACTERISTICS AND CURRENT MANAGEMENT PRACTICES ON HILLSLOPE AND CHANNEL ALTERATIONS

We know what these landslide processes are and how they operate. Limited quantitative data is available, however, on timber harvest impacts and on the magnitude of resulting slope and channel alterations in southeast Alaska. From 1984 to 1988, detailed aerial photographic analyses and a field mapping program were instituted jointly by the USDA Forest Service Juneau Forestry Sciences Laboratory and Tongass National Forest - Chatham Area to address the effects of controlling characteristics and timber harvest activities on where landslides occur, how they occur, and their impacts downslope from the point of initiation. An aerial photographic survey of landslides occurring over the last 21 years (1963-1983) in forested terrain on the Tongass National Forest provided region-wide data on landslide type, frequency, distribution, and general relationships to harvest activities. In the field, landslide failure, transport, and deposition zone characteristics were determined or measured at selected sites to provide more detailed information on size, quantity of sediment temporarily stored on the slope, and the quantity of sediment delivered to the valley floor and stream channel in harvested and non-harvested areas.

Aerial Photographic Survey

This survey involved the location, typing, and terrain characterization of all post-1962 landslides greater then 77 m^3 (100 yd^3) in initial failure volume. The same sample restrictions as those used in the pre-1962 study applied here because of similar photographic scales and resolution limitations. Map transfer of all identified failures was made to standard U.S.G.S. 15-minute quadrangle maps at a scale of 1:63360, using a zoom-transfer stereoscope. As part of the inventory process, slope gradient, failure zone elevation, and initial failure area were estimated from the aerial photos and topographic maps by use of parallax bar and hand scaling. Estimates were also made of slope run length (meaning the distance from failure site to deposition site). No estimates of the deposition area were made because of the difficulty in defining deposition zone boundaries in all but the most recent failures.

Using aerial photographs taken between 1971 and 1984, 1395 discrete landslides were identified and mapped. None of these landslides were identifiable on 1962 photos so that each is assumed to have occurred within the twenty-one-year period 1963-1983, a period which essentially bridges the development of large-scale clearcutting in southeast Alaska. Of this total number of landslides 103, or about 7%, occurred in clearcut areas or were directly associated with timber harvesting (Figure 2). Fifteen landslides were identified as being associated with road construction, but these are not considered further here. The greatest number of landslides (1277) occurred in uncut areas. If we consider these processes in terms of their occurrence rate per unit of land area, the response of landslides to timber harvesting is clearly illustrated. Using the most current data available for the Tongass National Forest[2], the occurrence rate of natural landslides over this 20-year period (1277 landslides distributed over 41,503 km^2) is 1.5×10^{-3} landslides/square kilometer/year.

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[2]These data were obtained from USDA Forest Service, Tongass Land Management Planning Team, 8505 Old Dairy Road, Juneau, AK 99801. Data were generated using a Geographic Information System for the Tongass National Forest.

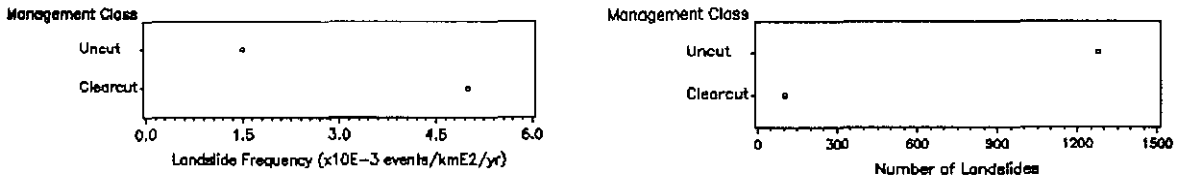


Figure 2. Comparison of landslide occurrence in cut and uncut areas in southeast Alaska based on aerial photographic analysis.

The landslide occurrence rate in harvested areas over this same time period (103 landslides distributed over 980 km^2) is 5.3 x 10^{-3} landslides/square kilometer/year, or 3.5 times the natural rate. This agrees well with the acceleration rate (4 times) reported for post-logging landslide activity at Hollis, Neets Bay, and Gedney Pass, the first areas to undergo large-scale clearcut logging in southeast Alaska (Bishop and Stevens, 1962).

On a region-wide basis, without regard to management disturbance, 77% of all landslides are of the debris avalanche/debris flow type and 23% are debris torrents (Figure 3). These results differ by about 10% from those derived from the earlier pre-logging survey and indicate a larger number of debris torrents relative to debris flows occurred during the sampling period. We are unable to account for this difference, but timber harvesting does not appear to have had an appreciable effect since respective percentages of these failure types for cut and uncut areas are very similar. Seventy-five percent of all landslides identified occurred on slopes with gradients in excess of 34 degrees (67%) (Figure 4), a value which approximates an average effective angle of internal friction of many of the undisturbed, coarse-grained soils derived from colluvium and glacial till in southeast Alaska (Swanston, 1967, 1969, 1970). On these soil types, the effective angle of internal friction controls the inherent stability of the material and defines a boundary of critical risk above which landslides are likely to occur with any kind of disturbance. An additional 15% occurred on slope gradients between 26 and 33 degrees (49%-66%), a gradient range which brackets the lower limits of the effective angle of internal friction of these soil types (Schroeder and Swanston 1987), and defines a zone of potential risk requiring careful planning, layout, and engineering before any kind of entry. The remaining 10% of landslides were identified on lower gradient sites and probably reflect local zones of higher gradient undetected on the photographs or failures occurring in elevated marine clays and glacio-lacustrine deposits which have characteristically lower angles of internal friction.

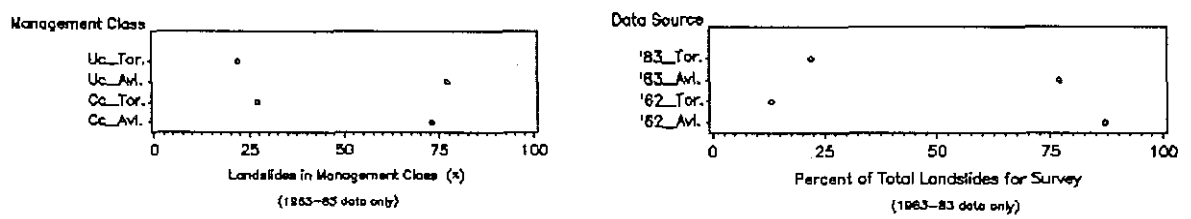
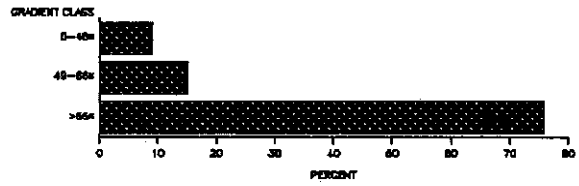


Figure 3. Comparison of landslide type occurrence in southeast Alaska based on aerial photographic analyses. Codes: '62 = pre-1962 survey; '83 = 1963-83 survey; Tor. = Debris torrent/flood; Avl. = Debris avalanche/flow; Uc = Uncut; Cc = Clearcut.

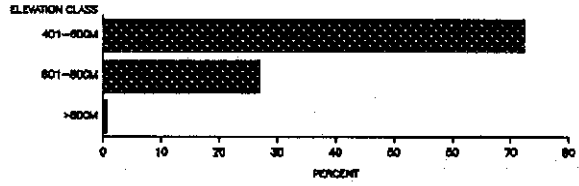
The majority of landslides also occur within a limited range of elevations, with 79% of all failures occurring within a band between 100 and 500 meters (328 to 1640 feet) (Figure 5). On these convex, glacially modified slopes, this range encompasses the greatest proportion of surface area and corresponds to the zone of steepest gradient where most failures can be expected. It also encompasses a substantial portion of the commercial forest land on the Forest and is subject to increasing disturbance from harvest entries.

Figure 4. Distribution of landslides by gradient class in southeast Alaska without regard to management area, based on regional aerial photographic analysis.



Only 14% of all landslides occur on slopes with northerly aspects (NE, N, NW). The remaining 86% are initiated on warmer sites or sites controlled by the northwest-southeast structural trends of the valleys and ridges in southeast Alaska (sites with E, SE, S, W, and SW exposures). Such sites receive the

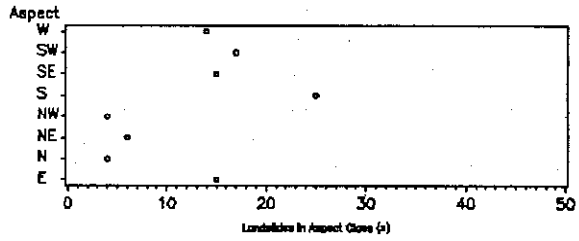
Figure 5. Distribution of landslides in southeast Aalaska by elevation class without regard to management, based on regional aerial photographic interpretation.



majority of the low-angle solar radiation prevalent at these latitudes and are exposed to major frontal weather systems moving in from the north Pacific (Figure 6). This suggests that aspect may have an important influence on slope stability in southeast Alaska. Constant exposure to high intensity fall storms provides the necessary excess water to generate temporary water tables at unstable hillslope sites. Possible differences in snowpack development and seasonal melting may also play a much greater role in landslide occurrence then previously thought by providing increased soil water levels both earlier and later in the year on southern aspects, and facilitating more rapid development of temporary water tables during storms.

Only about 3% of all the failures counted reached potential anadromous stream channels, defined as perennial channels with no major obstructions and gradients below 12%.

Figure 6. Association of landslide initiation sites with exposure along cardinal compass directions.



T-tests were used to test whether differences exist in landslide size and location characteristics at cut and uncut sites. Initial data analysis revealed that most distributions were not normal and that variances for cut and uncut groups were not equal. Therefore, approximate t statistics were calculated using unequal group variances and estimated degrees of freedom (SAS Institute, Inc., 1988). Results of these tests are shown in table 1.

Nonparametric tests of the same variables yielded the same results as did the t-tests and help to confirm these findings. There are significant differences in the general character of landslides in cut and uncut areas. Landslides in uncut areas are significantly larger, occur at higher elevations, develop on steeper gradients, and travel greater distances. In part, this is a reflection of more stable conditions over broader areas of undisturbed slope. On undisturbed slopes with a substantial old-growth timber cover, larger or more intense triggering events are needed to initiate a failure, and failures tend to develop where

maximum stress or minimum strength conditions exist, such as where steeper slopes, shallower soils, greater ground water convergence, and more rapid water table developments occur.

Field Survey

This portion of the study involved detailed mapping and sampling of individual landslides from headwall to the toe to define site characteristics not interpretable from aerial photographs. Sampling was carried out in both cut and uncut areas and on both the northern and southern portions of the Forest in order to ascertain any differences in these characteristics. Because of high management interest and logistical ease, sampling was concentrated in areas of active harvesting and with a well developed road network. These areas encompassed the east side of Chichagof Island and central and northern Prince of Wales Island. A total of 164 landslides were mapped, 71 in the norther portion and 93 in the southern. All of these landslides were of the debris flow type.

A comparison of initial failure sizes, transport distances, erosion in the transport zones, and volumes of deposited materials at the base of the hillslope and delivered to channels, supports the findings of the regional survey and indicates that landslides are larger and potentially more damaging in unlogged portions of the Forest. All of these variables are significantly different at the 1.0% level. However, statistical analysis of failure zone depth clearly demonstrates that this landslide characteristic remains unaffected by timber harvest. A t-test comparing the two management regimes indicates that there is insufficient evidence available to reject the assumption that failure zone depth is the same in cut areas as in uncut areas (Table 1).

Table 1. Statistical test results for comparison of landslide dimension and location characteristics, cut and uncut areas of the Tongass National Forest.

Landslide Feature	Mgt. Class	Sample Size	Mean	Standard Deviation	t Stat.	Degrees of Freedom
Headwall Elevation (m)	cut uncut	103 1275	637.0 1088.0	313.0 547.0	13.14	158.5
Failure Slope (degrees)	cut uncut	103 1275	33.0 40.0	9.4 8.5	7.57	1375.0
Failure Zone Length (m)	cut uncut	103 1275	38.0 55.0	17.5 33.0	8.53	167.7
Failure Zone Width (m)	cut uncut	103 1275	23.0 31.0	11.4 22.8	5.92	177.0
Volume of Failed Material (m^3)	cut uncut	103 1275	313.0 610.0	300.0 870.6	7.76	277.7
Headwall to Toe Distance (m)	cut uncut	103 1275	174.0 265.0	155.1 263.6	5.40	154.5
Failure Zone Depth (m)	cut uncut	103 1275	0.7 0.7	0.5 0.4	0.33	155.0

Note: Data are from the 1963-1983 aerial photographic survey for all features except Failure Zone Depth which uses Field Survey data (see text for explanation). All t statistics have an occurrence probability of less then 0.0001 except for Failure Zone Depth (P = 0.74). All tests except for Failure Slope used unequal variance procedures and estimated degrees of freedom (SAS Institute Inc., 1988).

Nonparametric tests yield results which also strongly support this conclusion. Soil depths to bedrock are generally less then 2 m for the steep to very steep slopes where landslides most often occur in southeast Alaska. With the apparent lack of deep-seated mass movement processes, soil depth is probably the primary control of failure depths in this region. Since timber harvest does not change soil depths, it seems reasonable that failure depths in cut and uncut areas should not be different. Failure zone depths are generally less then 1.0 m, with 50% of the values falling between 0.36 m and 0.86 m. The fact that failure zone depth is so consistent was used in estimating erosion volumes in the aerial photographic survey.

Along with quantitative measurements of failure and flow characteristics, notations of microtopography and parent material type were also made for each initiation site. In unlogged areas, more then half of the landslides (58%) originated in shallow, poorly defined depressions less then 1 m deep. An additional 32% developed in well-defined depressions or swales 1-3 m deep. Such depressions are generally well drained and serve as major subsurface drainage paths. During storms they focus converging ground-water flows from upslope to create zones of local saturation and temporary water table development, a process identified as a major triggering mechanism for landslides in southeast Alaska (Swanston, 1974; Sidle, 1985). Only a small number of deeply incised, structurally-controlled gullies (>3 m deep) were directly involved in initial failure (10% of sample). In logged areas, the number of structural gullies involved in initial failure is substantially increased (30% of sample), possibly reflecting the increased disturbance of gully walls and loading of the gully floor with soil and organic debris during yarding operations.

Eighty-eight percent of all landslides sampled in unlogged areas occurred in shallow colluvial soils overlying bedrock. Only a small percentage (approximately 12%) occurred in shallow soils derived from glacial till. This is in sharp contrast to the landslides occurrence in logged areas, where over 45% of the landslides occurred in soils developed over glacial till. This represents a four-fold increase in till-related failures at clearcut sites and indicates a substantial reduction in the stability of this material as the result of ground surface disturbance and overstory removal.

CONCLUSIONS

Timber harvesting in southeast Alaska has had a significant influence on size, frequency, and location of landslides. The frequency or rate of landslide occurrence in clearcut units is 3.5 times that in unlogged areas. Landslides in clearcuts also occur at lower slope angles and elevations than do landslides from uncut areas. However, landslides in clearcuts tend to be smaller, and travel shorter distances than their counterparts from undisturbed sites.

Under natural, undisturbed conditions, most failures occur associated with shallow linear depressions ranging from 1-3 m deep and are probably initiated by excess water from upslope converging into these depressions. Only about 10% occur in gullies. In contrast, more than 30% of landslides from clearcut units are initiated in gullies, probably reflecting the destabilizing effect of vegetation removal and yarding on gully sidewalls, and the increased accumulation of unstable debris on gully floors. The number of landslides occurring at sites underlain by glacial till is also substantially increased in clearcut units, reflecting the destruction of stabilizing root systems on these normally heavily vegetated sites.

Three-quarters of all failures, regardless of management activity, are initiated on slope gradients of 34 degrees or greater, a value which approximates a critical angle of stability for these hillslope soils. Eighty-six percent of these failures also developed on warmer, southerly aspects suggesting that aspect may substantially influence slope stability, possibly through its effect on hillslope water balance conditions.

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"DUMP CREEK: A MAN MADE ECOLOGICAL DISASTER"

Elizabeth Rieffenberger, Forest Hydrologist, Salmon National Forest, Salmon, Idaho, and Dan Baird, Branch Chief, Recreation, Range, Wildlife and Watershed, Salmon National Forest, Salmon, Idaho

INTRODUCTION

Placer mining for gold was an important event in the Salmon River Mountains from the late 1860's to the turn of the century. During this time a significant placer mining operation was carried out in the Moose Creek drainage near Salmon, Idaho. As a course of the mining activity in the Moose Creek area a tunnel was cut from the Moose Creek drainage into the adjacent Dump Creek drainage for disposal of waste rock from the placer operation. Upstream of this tunnel a dam was constructed on Moose Creek to impound water for mining purposes. A commonly held belief is that a flood event occurred which breached the dam releasing the impounded water which flowed downstream and was diverted into the tunnel and the Dump Creek drainage. This created a gully which caused the waters from Upper Moose Creek to flow down Dump Creek. Because the area has been extensively placer mined it is impossible to determine the exact original channel locations prior to the water diversion. It appears that a low hydrologic divide separated the Moose Creek drainage from the head of the Dump Creek drainage. As a result of this water diversion channel downcutting and massive slope failures occurred in the Dump Creek drainage.

Prior to the water diversion Dump Creek had a drainage area of approximately eight square miles with natural flows in the range of .5 to 10 cfs. In contrast Upper Moose Creek has a drainage area of approximately 25 square miles with flow volumes ranging from several cfs to over 100 cfs during snowmelt runoff. Flood events in excess of 400 cfs have occurred on Moose Creek. Because of its homogeneous aspect and elevation the snowmelt from the Upper Moose Creek drainage occurs in a relatively short period of time causing high peak flows.

Dump Creek with the increased flows from Upper Moose Creek downcut through the unconsolidated sedimentary and volcanic materials that were found in this drainage until a deep chasm developed. Channel downcutting caused the side slopes to be undercut resulting in massive slope failures. In places the existing chasm is up to one-half mile wide and 300 feet deep. Massive slope failures deposited large volumes of material in the Dump Creek channel that would flush out during snowmelt runoff and high intensity storms into the Salmon River. This material was predominately transported as suspended sediment down the Salmon River. The coarse bedload from the drainage formed a large alluvial fan at the mouth of Dump Creek and bar formations in the Salmon River below Dump Creek. As of 1974 an estimated 9 million cubic yards of material had been transported from Dump Creek into the Salmon River.

MITIGATION

One of the earliest records of an evaluation of the Dump Creek problem was a January 10, 1950 report from the Salmon National Forest to the Regional Forester proposing to divert the water from Dump Creek to Moose Creek. At that point in time the project apparently died when someone from the Regional Office in Ogden decided that Dump Creek waters had never flowed down Moose Creek. In 1956, the Army Corps of Engineers worked on removing part of the alluvial fan at the mouth of Dump Creek to widen the Salmon River channel in hopes of eliminating the slack water above Dump Creek to stop the ice buildup and the upstream flooding resulting from the ice dams. They moved 12,500 cubic yards before winter weather shut them down. Before they could start up in the spring high flows from Dump Creek washed out their workings and built up the alluvial fan larger than it had been before their work. After further study the Corps decided that further work on Dump Creek was not economically justified for flood control purposes.

In the 1960's the concern over Dump Creek surfaced again and a study was initiated to determine the watershed restoration needs for the area. Four alternatives were reviewed: (1) Diverting Moose Creek back into its original channel. This would entail channel and diversion dam construction. (2) Construction of drop structures and retaining walls in Dump Creek to control velocity and store sediment. (3) Construction of a

flood control reservoir to store water during periods of high runoff and slowly release it over the summer. (4) Diverting the water back into Moose Creek plus mechanical treatment of the slopes adjacent to the Dump Creek chasm to speed up slope stabilization.

Alternative 1 to divert the water back into Moose Creek would remove the transport mechanism for carrying the eroded material into the Salmon River. Under this alternative the side slopes of Dump Creek would slough until they reached a natural angle of repose. A rough cost estimate of this alternative was $177,600 in 1968.

Alternative 2 was considered in depth but abandoned primarily because it was felt that it would be infeasible to construct structures large enough to store the anticipated sediment from the Dump Creek drainage. The planned sediment storage would handle only about 300,000 cubic yards of material. It was estimated that this would handle only about one additional foot of gully wall slough. At this time near the chasm head slabs of ground several hundred feet in width and 10+ feet in depth were cracking and sloughing into the chasm. In 1968, a rough estimate of the cost of this alternative was $4,700,000.

Alternative 3, a flood control reservoir, was considered cost prohibitive and would flood productive timber lands. Also because of the extreme water level fluctuation fishing and recreation opportunities associated with the reservoir would be minimal.

Alternative 4 involved mechanical stabilization of the Dump Creek chasm in addition to water diversion. The cost of this alternative was never estimated because the technical feasibility of stabilizing the slopes in Dump Creek with heavy equipment was questioned. This was not considered a viable alternative.

After evaluation of these four "action" alternatives it was felt that Alternative 1 was the most effective and economically feasible alternative. At this point an indepth hydrologic study was initiated on Moose Creek to evaluate the stability of the existing channel to determine if it could handle the anticipated streamflows. Following a thorough evaluation it was determined that Moose Creek, which is primarily located in granitic parent materials, was stable and there was no apparent opportunity for excessive downcutting. A concern still existed as to what effects rediverting the water into a channel that had been conditioned to significantly lower flows for 70 years would have on the channel stability and flood flows. A thorough review involving personnel from the Forest, Regional and Washington Offices, and Research determined that the existing Moose Creek channel had carried higher flows in the past and would be capable of handling the increased flows after some channel clearing.

In 1974, a Project Plan was completed and efforts initiated to secure funding for the Dump Creek Project. This proposed project consisted of the following:

1. Construction of a water diversion structure with control gates to divert the water back into Moose Creek.

2. Construction of about 6,000 feet of stream channel below the diversion structure.

3. Vegetation removal in the historic Moose Creek channel that had encroached on the channel in the past 75 years. The estimated project costs in 1974 were $405,300.

Construction of about one mile of new channel below the diversion structure was necessary because placer mining in this area had obliterated the original stream channel. Because of the proximity of the new channel to Dump Creek, about 4,000 feet of the new channel was lined with an impermeable membrane to reduce subsurface seepage from the new channel. The concern was that subsurface seepage might lubricate the unstable side slopes in the Dump Creek channel.

Funding for the approved project was received in 1977. Starting that fall some channel clearing was initiated and finished up the summer of 1978. Final engineering design was completed in the winter of 1978 and the project contract was awarded in September.

Construction activities commenced in the fall of 1978 and were completed by the fall of 1979. These activities included construction of the diversion structure, the new channel, and the drop structures which were designed to control the channel gradient in the new channel. Also included in the project package was construction of a treated timber bridge, access road and protective fencing.

The designed diversion structure is a small earthfill dam with a spillway and outlet works. An overflow spillway was designed to carry flows in excess of 600 cfs. Flows in excess of the 600 cfs, the designed 100 year flood flow, would flow into the Dump Creek channel. An outlet structure to release the water into the new channel was designed so that flows could be regulated in the new channel to condition it to increased flows over a several year period.

The new channel was excavated to connect the diversion structure with the historic channel. After excavation the PVC liner was placed in the channel and keyed into the banks. Fifteen drop structures constructed of rock filled gabion baskets were placed in the new channel to control channel gradient. The drop structures were designed to keep the channel gradient under .5 percent in the unlined segment and .25 percent in the lined channel. Finally a two foot cover of pit run material from the placer tailings was placed on the liner. The original design called for a sand blanket to be placed on the liner, but the manufactures felt that the rounded tailing materials would not puncture the liner. The final contract cost for the project was $526,063. This amount did not include the force account work done on channel clearing, engineering and contract administration, or the cost of acquisition of private land necessary to complete the project.

In the fall of 1979 water was finally diverted into the newly constructed channel. Numerous discussions and consultations were held to determine what volume of flow should be released into the new channel during the first spring runoff. The initial proposal was to release one half of the design flow, or 300 cfs, the first year. This was scaled down to 130 cfs for the initial release to allow for some deposition of fines on the channel bottom to reduce the permeability of the channel materials covering the liner.

Initially, several problems were observed in the newly constructed channel. There was some channel scouring which exposed the liner below the drop structures. Voids appeared in the gabion baskets at the drop structures from disintegration of the rounded, weathered rocks which were used to fill the baskets. The voids in the gabions were refilled with more competent rock and riprap was placed below the drop structures were the gabions were scouring. Eventually, the drop structures were altered to reduce the scouring action resulting from the hydraulic jump below the lower gabions.

Additional channel clearing was required in the existing channel below the constructed channel following the water diversion. There was considerable concern over some downcutting in the channel above the tailings ponds. This situation was observed for several years to determine if any remedial work would be required. Eventually, the channel bed became armored and the downcutting ceased.

During the high flow of 1984, a considerable volume of water was observed flowing over the dam spillway. At this time a review of the spillway design showed that the spillway did not have the capacity to handle the design flow. An error in the choice of hydraulic equations was determined to be the cause of the inadequate spillway capacity. In 1988 the spillway was reconstructed by widening the weir and the cross sectional area of the downstream spillway.

In retrospect it is apparent that changes in the original drop structure and spillway design would have prevented some of the maintenance costs experienced on this project. To date the total maintenance costs on the Dump Creek Project over the last ten years are approaching $100,000. Currently, all the features of the project are functioning as planned and no additional major maintenance needs have been identified.

MONITORING

The Dump Creek Project Monitoring Program was initiated in 1979 to document the prediversion conditions in the project area. Permanent photo points and transects were established at that time. Project monitoring has continued since then to document the conditions since the water diversion.

Several items of concern have been addressed in the monitoring program. Channel monitoring has been designed to assess the impacts, both beneficial and detrimental, on the Dump Creek and Moose Creek channels. Mass movement of the unstable banks adjacent to Dump Creek has been monitored by extensiometers and convergence meters. The uppermost headcut on Dump Creek has been monitored to detect any upstream migration following water diversion. An other area of monitoring has been the critical section where the new channel and Dump Creek are the closest. This area has been monitored to detect any subsurface seepage from the new channel. In addition some water quality monitoring has been done to assess water quality changes as a result of the project.

Monitoring during 1989 showed that the Moose Creek channel has adjusted to the increased flows and any initial downcutting which occurred in the channel below the constructed portion has stopped and for the most part the bed is armored and the banks are stabilizing. In the constructed portion of the channel the banks are revegetated and the drop structures, though now functioning more as a chute, are stable and the scouring below them has ceased.

The Upper Dump Creek channel between the diversion structure and chasm has significantly stabilized. In this reach the downcutting was minimal, relatively speaking, and the raw banks were less than 30 feet high. No movement of the uppermost headcut has been detected. Trees over 15 feet tall are growing in the channel bottom which prior to diversion scoured to the extent that there was almost no vegetation present. The slope in the critical section, where the two channels are closest, has stabilized and no additional bank sloughing has occurred in this vicinity since the water diversion.

Dump Creek below the waterfall where the chasm begins will continue to erode for centuries. Mass land movement as a result of undercut slopes will continue for an indefinite period of time. These unstable slopes will continue to slough until a natural angle of repose is achieved. Water from several small drainages, tributary to Dump Creek below the diversion, still flows down Dump Creek. However, this small volume of water is incapable of carrying the material once transported down Dump Creek.

The alluvial fan at the mouth of Dump Creek has showed significant signs of stability in recent years. Prior to water diversion very little vegetation grew on the fan because peak flows braided across the fan and the channels were constantly changing. Now with the reduced flows a distinct channel has developed across the fan and riparian vegetation is rapidly establishing on the fan.

A significant improvement in the water quality in the Salmon River has been observed since the sediment loading from Dump Creek has essentially been stopped. No longer is the unmistakable sediment plume from Dump Creek observed every spring along the Salmon River.

RECLAMATION OF SOUTHEAST TENNESSEE'S COPPER BASIN

By Roger W. Bollinger, Manager, Reclamation Program, Tennessee Valley Authority, Norris, Tennessee

ABSTRACT

In 1843 copper was discovered in an area of southeast Tennessee and north Georgia. Crude smelting (heap roasting) techniques, logging of timber for fuel for open-pit roasters, open range grazing, and annual burning of lesser vegetation saw, by the 1920s, over 23,000 acres totally denuded and another 9,000 acres severely impacted by these activities--the largest contiguous denuded area in the eastern United States. Smelting resulted in high concentrations of sulfur dioxide (SO_2) which settled into the soils lowering pH and further reducing any chance of natural vegetative recovery. Severe soil erosion and gullying resulted. Water quality in the Ocoee River was degraded and uses of three Tennessee Valley Authority (TVA) reservoirs and hydrogenerating plants have been diminished.

Revegetation efforts were initiated in the 1930s. Since then several government agencies and private companies have researched the problems and implemented various onsite treatments. This paper reports on efforts to control soil erosion through establishment of vegetative cover. For the first time since the environmental degradation began, a reasonable end can be seen.

INTRODUCTION

Deserts: landscape commonly associated with the western United States or other countries. And, in its rightful place it is a thing of special beauty and interest. Yet, out of place, it becomes a stark, naked blight on the land and sometimes a reflection of man's follies with his natural environment. This is a situation I wish to present to you today, a story of a desert location (7)[1] in the southeast corner of Tennessee known as the Copper Basin.

The basin is surrounded by verdant green with an average annual rainfall of 58 inches. Once it, too, yielded lush stands of upland hardwood and pine forests common to its surroundings. It was home to the Cherokee Indians who frequented these hills and valleys of the southern Appalachian Mountains. Its clear streams meandered through the basin, emptying into the Ocoee River on its rush through the Ocoee Gorge to the Hiwassee and Tennessee Rivers.

The denudation of the basin lead to the single largest contiguous barren landscape in the eastern United States. It points to man's insensitivity to his natural resources, but also illustrates what man and time can change.

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[1]Numbers in parentheses refer to references in Literature Cited.

It is a lesson we should learn from and apply as we become ever mindful of our environment and that of our world.

BACKGROUND

Location

The Copper Basin is located in a basin-like landform at the junction of the States of Georgia, North Carolina, and Tennessee. Elevations within the basin range from 1,500 to 1,800 feet above sea level. The steeply rolling to hill-like terrain is surrounded on the north, east, and west by mountains ranging from 2,000 to 4,200 feet in elevation. All told, the basin covers about 60 square miles of the western side of Polk County, Tennessee, reaching southward across the Ocoee River into Fannin County, Georgia. Cherokee County, North Carolina, forms the eastern boundary. Copperhill and Ducktown, Tennessee, and McCaysville, Georgia, are the largest communities found within the basin.

Geology and Soils

A limited background on the geology of the Copper Basin and specifically the Copper Basin/Ducktown District places the basin in the Blue Ridge metamorphic province of Tennessee, Georgia, and North Carolina (7). The lithology consists of metamorphic rocks found within the Great Smoky Group of the Ocoee Supergroup. The Copperhill formation, found within this group consists of metagraywacke, mica schists, and metaquartzite hosting nine massive sulfide deposits. The deposits are approximately 65 percent massive sulfides and 35 percent gangue minerals. The mineralization is composed of approximately 60 percent pyrrhotite, 30 percent pyrite, 4 percent chalcopyrite, 4 percent sphalerite, and 2 percent magnetite (14).

Basin soils are placed in the Evard soils series. Evard soils consists of deep, well-drained loamy soils formed in residuum of acid crystalline rock commonly associated with low mountains and foothills. Slopes range from 10-40 percent. Upper horizons are brown to strongly brown in color with a loam to clay loam structure. It is friable with a few fine flakes of mica, and strongly acid. B horizons are yellowish red to red in color. also of clay loam; friable and very strongly acid. The even lower C horizon occurs as a saprolite of granite that crushes to a sandy loam, red to yellowish red in color. Solum thickness ranges from 30-40 inches. Depth to hard granite gneiss ranges from 5-12 feet. Reaction is strongly acid or very strongly acid throughout (14).

The inherent colors of the Evard soils aptly reflect denuded portions of the basin to this day. The U.S. Soil Conservation Service (SCS), through personal discussions, noted they had made some efforts to estimate soil loss in the basin. Their estimate indicated, on average, some 4 feet of upper soil horizons have eroded away over the past 125 years. Only the yellowish-red to red subsoils typical of the lower horizons remain giving the basin its rich, desert-like quality. These subsoils are poor in nutrients, high in metals and very acid--all of which complicates restoration of vegetation.

MINING AND RESULTANT ENVIRONMENTAL IMPACTS

The discovery of copper in the basin in the mid 1840s led to the start-up of small scale (underground) mining and smelting activities by the 1850s. As rail lines were laid into the basin in 1891, mining accelerated significantly. These early mining operations relied on a crude smelting method called "heap roasting" or open burning of copper ore to purge the sulfur-laden impurities.

Layers of wood cut from the surrounding countryside were alternated with layers of ore and then set on fire. The numerous huge piles burned constantly and as the metal was recovered new fires were started. This activity, for the most part, continued around-the-clock up to the turn of the century. Thick clouds of fumes and smoke lay in the basin year-in and year-out. At times the smoke was so thick that mule teams hauling ore or copper wore bells to prevent collisions (2), (7).

As the smoke settled back to the earth, its acid nature, combining with generally acid soils, rainfall, and the rapid deforestation for wood to fuel the smelting fires, made it more and more difficult for vegetation to reestablish. Additionally, open range grazing of cattle and indescriminate burning of pastures and forests accelerated the loss of vegetation (7), (9). As the forest cover was removed, even stumps were uprooted to meet the insatiable demand for wood to fuel the smelting fires (3), (12). By 1875 no vegetation of significance was left on a large part of the basin. Eventually, over 50 square miles (32,000 acres) was affected with over 23,000 acres denuded. Vegetation on peripheral areas was badly damaged or stunted by the fumes.

Newer smelting processes were adopted in 1907. This led to the recovery of the SO_2 gases for the manufacture of sulfuric acid, thus lessening air pollutants. A slow but steady improvement to the basin's air quality began and gradually offered the first real chance to initiate revegetation efforts (9).

Soil erosion was a prime result of the denudation occurring in the basin. TVA studies in the 1940s showed that barren lands were eroding at a rate of 39 acre-feet/mile^2/year. This was in comparison to only 0.44 acre-feet/mile^2/year (1 ton/acre/year) across the rest of the Ocoee River watershed (13). A similar study by TVA in 1951 showed a rate of 69 acre-feet/mile^2/year or 1.8 times greater than the 1944 estimates (9). EMPE Incorporated, a consultant firm, employed by Tennessee Chemical Company (TCC) studied erosion rates in 1987-88 in two subwatersheds and noted similar findings (195 tons/acre/year) in the unreclaimed watershed (5).

The highly mineralized soils washing into receiving streams also affects water quality. High levels of iron, manganese, copper, lead and zinc are common in waters below the basin and in portions reaching levels toxic to aquatic life (5), (6), (9). Sediments reduce water storage space and hamper electric power generation at TVA's downstream hydroelectric facilities. Periodic sluicing of sediments is required at the Ocoee No. 3 Dam to keep penstocks clear. The river's condition also detracts from the recreational

experience by the multitude of whitewater rafters and others using it (9). Keeping soils onsite will significantly improve the river for many purposes.

EARLY REVEGETATION

Revegetation efforts began in the 1930's with the development and enhancement of public conservation agencies, and with the improving interest by mining companies, cooperative revegetation opportunities soon materialized. The Tennessee Extension Forester, the U.S. Forest Service (USFS), and the U.S. Bureau of Plant Industry began small scale plantings on peripheral areas where some topsoil and ground cover existed (9).

These early efforts were expanded in 1939 by TVA in a joint undertaking with the Tennessee Copper Company. In 1941, TVA established a Civilian Conservation Corps (CCC) camp which accelerated the reclamation efforts. TVA also set up a comprehensive research program to identify trees, grasses, and leguminous plants that would best adapt to these harsh conditions. While several plants showed possibilities, loblolly pine (Pinus taeda L.) has been the tree species of preference because of availability, adaptability, consistency in response and ultimate forest product use. Other species included Virginia pine (Pinus Virginiana Mill.) and black locust (Robinia pseudoacacia L.) in gullies and on ridgetops. The grasses and legumes that showed promise included weeping lovegrass (Eragrostis curvula (Schrad.) Nees) and sericea lespedeza (Lespedeza cuneata) (9), (12), (13). However, establishing ground cover did not become a standard practice until later periods.

In 1945 TVA presented a report (13) to Tennessee Copper Company, summarizing years of research and outlining an overall effort to reclaim the basin. While a large scale reclamation effort was never implemented, the company continued its annual effort to hand plant tree seedlings.

In 1954 the company employed an agricultural specialist to formally oversee the reclamation. Tree planting continued to be the main activity but along some of the wider and flatter ridgetops, legumes were seeded in with both pine and locust plantings. Additional research efforts with State and Federal agencies and Tennessee, North Carolina, and Georgia universities also occurred. Other plants, kudzu (Pueraria lobata (Willd.) Ohwi) and Japanese fleeceflower (Polygonum cuspidatum Sieb. and Zucc.) were tried. However, their use has been discontinued because of the competitive nature of kudzu and until more was known about the compatibility of fleeceflower with other plants (9), (10), (12).

Cities Service Company bought the operation in 1963. It not only continued but accelerated revegetation activities and in 1973 entered into a five-year research effort with the USFS's Southeastern Forest Experiment Station (3), (10). Studies by the SCS and the University of Tennessee's Plant Materials Committee helped with revegetation recommendations and plans. Limited aerial seeding and fertilization was also tried (10). The company field tested and adopted use of fertilizer tablets planted along with tree seedlings (1). Results showed greatly improved survival and early tree growth.

During the early 1980's the SCS carried out two significant activities. One, in Tennessee, was designed to maximize revegetation and surface water control, another reforested many of the remaining denuded lands in the Georgia portion of the basin (11), (12). The Tennessee project demonstrated significant land grading, use of rock checkdams, hydroseeding grasses and legumes, using erosion control netting, and direct seeding black locust. Costs approached $4,000 per acre (9). The Georgia effort limited site preparation to deep subsoiling or "ripping" and planting superior loblolly pine seedlings donated by Bowater Incorporated (3), (9), (13). Fertilizer tablets were also set with the pines. Costs for this effort was $625 an acre.

From the 1930's to about 1982, these activities along with volunteer encroachment of plants on perimeter lands saw nearly two-thirds of the basin reclaimed or reforested. This included the planting of some 14.5 million seedlings and establishment of ground cover on limited areas. Nevertheless, over 12,600 acres remained in need of some level of reclamation to control erosion and the influx of sediment and heavy metals into nearby streams.

CURRENT RECLAMATION

New opportunities for expanded reclamation developed in 1982 with acquisition of the properties and facilities by TCC. Also the Blue Ridge (Georgia) Soil and Water Conservation District approached TVA's Board of Directors for assistance in reclaiming denuded lands on the Georgia side of the basin (11). As previously noted, this group had already established trees on these lands, but no ground cover had been incorporated and soils continued to erode. TVA's Water Quality Department offered to help fund expanded reclamation work in Georgia and in Tennessee if the new company owners showed interest.

A cooperative agreement was completed with the Blue Ridge Soil and Water Conservation District in 1984 (11). Under this agreement, TVA would aerially seed and fertilize all remaining disturbed areas. The seed mixture consisted of an acid tolerant blend of grasses and legumes which included weeping lovegrass, sericea lespedeza, kobe lespedeza (Lespedeza striata), Kentucky 31 fescue (Festuca arundinacea, Schreb.), and the tree species, black locust. Commercial fertilizer (19-19-19) was applied at the rate of 600 pounds/acre.

While aerial seeding and fertilization was not a new approach, TVA's Reclamation and Aviation staffs had refined this approach, using helicopters, into a very efficient and cost-effective method for treating small, scattered mountainous sites in reclaiming abandoned non-coal mineral mines in western North Carolina and southwest Virginia. It was concluded that this was the most feasible method for treating even larger sites where tree seedlings had already been established, and in situations having extensive areas of severe gullies and thus largely not accessible to typical ground equipment (8).

Also during the period both the Reclamation and Water Quality Department staffs were meeting with TCC representatives to explore interest in cooperative reclamation activities. The company expressed interest in reforestation and establishing ground cover, but were concerned with overall costs. TVA pointed to the work planned for establishing ground cover in 1984 with the Georgia group. Perhaps, TCC would want to assess the helicopter seeding and fertilization. Since the company had recently planted trees on a

32-acre portion of adjacent Tennessee lands, they agreed to participate. If results and costs were favorable the company indicated a willingness to extend their efforts.

The process of testing and demonstrating techniques and encouraging the participation of others has long been an important element in TVA's approach. In this way cooperation and partnership roles have developed to accelerate reclamation in a number of project areas far better than a single entity could achieve.

This initial effort to seed and fertilize 32 acres in Tennessee and 28 acres in Georgia by helicopter worked well and within the estimated costs of slightly over $200/acre. Even though droughty weather set in following the spring seeding, response of weeping lovegrass was excellent with fair response occurring with the other species. Response by black locust was good, and, as a leguminous tree, it will add longer term nitrogen fixation for the previously planted pines. The fertilizer greatly benefited both the grasses and legumes and the established pines. Pines planted in the infertile basin soils typically show slow growth and the yellowish, weak color of chlorotic plants. Following fertilization, visible improvement in color and growth was readily evident.

With these early but visible results and cost experience, TCC elected to become a significant partner. They agreed to undertake site preparation or subsoiling, to lime soils where feasible, to purchase seed and fertilizer, and conduct tree and shrub plantings using soil moisterizers (9). TVA agreed to provide its helicopter treatment capabilities, additional seed and fertilizer, and provide technical assistance to the company for an extended period, with the ultimate goal of reclaiming the remaining problem lands.

Thus, in 1985 a new cooperative effort began. Both a spring and fall seeding was conducted. During the spring of 1985, 400 acres in Tennessee and 83 acres in Georgia were treated. Another 230 acres in Tennessee were treated in the fall of 1985. Better results occurred during the spring planting periods. This has become the norm. Trees and shrub seedlings are planted during the late winter or early spring period.

From 1985 through 1988 the region, including the Copper Basin, experienced some of the most severe droughts recorded, yet reclamation proceeded with very favorable results. Only in some instances was it necessary to reseed areas, although treated sites are refertilized about the third growing season. This assures that the herbaceous cover and trees are well established. The nitrogen fixing, leguminous plants also enhances the self maintaining capability of the vegetative cover.

In 1986 TVA published a report (9) that outlined the environmental problem associated with eroding basin lands, summarized the status of reclamation activities over the years, identified the remaining problem lands and proposed practical treatment techniques to achieve final results. The plan noted that 12,612 acres needed reclamation. This consisted of 2,406 acres of totally denuded land and 10,206 acres of partially vegetated land. Partially vegetated lands are those with various age class plantings of trees (predominately pine) but no ground cover (9).

In 1987, the Polk County Soil Conservation District published a cooperative erosion control plan in cooperation with TVA and TCC (12). In support of this plan the SCS prepared a proposed funding document (measure plan) to begin in 1990. Bowater Incorporated became a cooperator in a 1988 agreement with TCC whereby Bowater, under its landowner assistance program, would contribute approximately 150,000 improved loblolly and Virginia pine seedings annually. Also, in 1987, TVA's power program began contributing funds to this effort since reductions in sedimentation would benefit operation of their downstream reservoirs and hydroelectric plants. This combined effort is seeing significant results in reclamation with 2,435 acres treated since 1984. Only 10,177 acres remain to be reclaimed.

For this period, TCC committed $636,000, TVA $827,000, the Georgia Soil Conservation Service $52,000, the Tennessee Soil Conservation Service $28,000 (first of five commitments) and Bowater Incorporated approximately $18,000 in improved tree seedlings. Cooperative expenditures total $1.56 million for an average cost per acre of $641. TCC is also planting species beneficial to wildlife. These include autumn olive (Elaeagnus umbellata Thunb.) and bicolor lespedeza (Lespedeza bicolor, Turez.).

Cooperative results are paying off. Erosion along city streets and roadways in the basin is being lessened, and studies conducted by TCC's consultant, EMPE Incorporated, speak well of controlling runoff and sedimentation (8-10 tons/acre/year in reclaimed watersheds) (5). While additional studies would be desirable to document restored ground cover, enhanced tree growth due to fertilization and the addition of leguminous plants, reductions in temperature extremes, rebuilding soil and improvements in aesthetics, we know from past experiences and current observations that these are now tangible results. The available, but limited funds, are better spent in achieving actual on-the-ground results. However, others may want to study and report on these improvements.

SUMMARY

For nearly 150 years the Copper Basin has been a major source of sediments in the Ocoee River. Mining, and particularly the smelting of copper ore, was the culprit. With the discovery of copper in 1843 the basin underwent drastic changes and today still remains as a significant nonpoint source of pollution. However, with nearly a half century of various kinds and levels of reclamation, over two-thirds of the basin's 32,000 acres (50 square miles) is on the road to recovery.

Once, the degraded water quality and poor aquatic habitat of the Ocoee River downstream was accepted because the goal of revegetating the denuded lands in the Copper Basin seemed unachievable. However, through cooperative efforts of various private companies and government agencies, control of erosion from the Copper Basin is now an attainable goal (4). Since 1984, 2,435 acres have been reclaimed leaving only 908 acres of denuded lands and 9,269 acres of partially vegetated lands. With continued activities and reasonable funding by cooperators, the job can be accomplished.

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PLACER MINING AND SEDIMENT PROBLEMS IN INTERIOR ALASKA

by Bruce P. Van Haveren, Supervisory Hydrologist, U.S. Bureau of Land Management, Lakewood, Colorado, and Adjunct Professor, Colorado School of Mines, Golden, Colorado

INTRODUCTION

The natural resource conflicts associated with placer mining in interior Alaska have been well documented (USDI-BLM, 1988; Dworsky and Levine, 1989; Van Haveren, 1989). In this paper I explore the fluvial issues associated with placer mining in the Birch Creek watershed, which drains a large portion of the Circle Mining District in interior Alaska. Specifically, I discuss mining-sediment relationships, stream behavior, and valley-floor stability.

AREA DESCRIPTION

The Birch Creek watershed is located approximately between 65 and 66 degrees north latitude and between 144 and 146 degrees west longitude and has a drainage area of 5570 km2 at the Steese Highway Bridge (Figure 1). Birch Creek ranges in elevation from approximately 120 m at its confluence with the Yukon River to approximately 1500 m at the watershed divide. A sixth-order stream, Birch Creek drains about one-eighth of the total area of the Yukon- Tanana

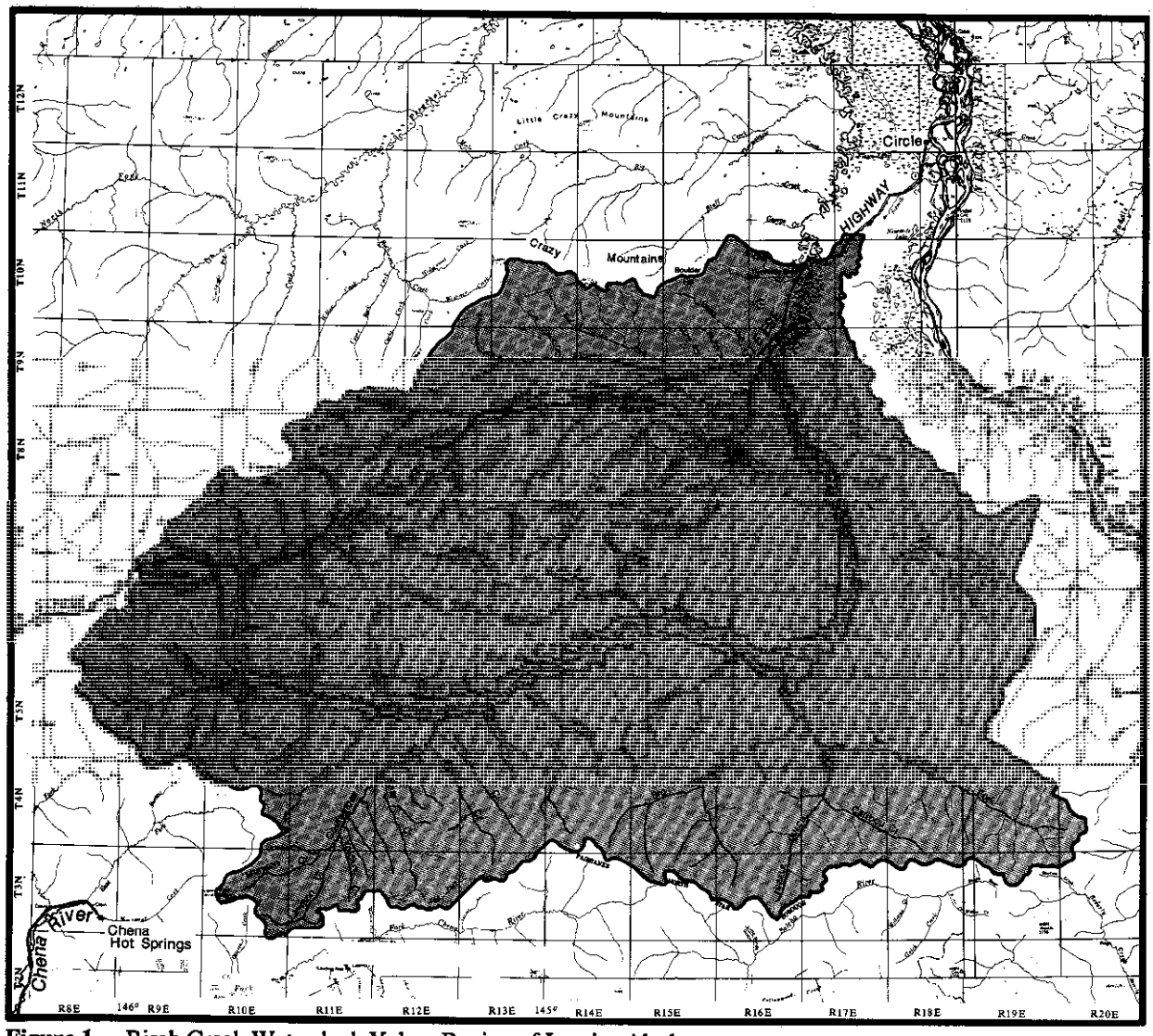

Figure 1. Birch Creek Watershed, Yukon Region of Interior Alaska.

Uplands Physiographic Province, which is part of the great central plateau province of Interior Alaska. This Region is a rolling upland characterized by discontinuous groups of higher mountains and ridge crests of relatively uniform height. Ridge tops vary from about 800 m to nearly 1500 m above sea level; a few summits exceed 1500 m.

The geology is characterized by early pre-Cambrian Birch Creek schist with narrow bands of Quaternary alluvium occupying the valleys of Birch Creek and its major tributaries. The Birch Creek schist consists of recrystallized sedimentary rocks which are very resistant to erosion. Chemical weathering does not readily occur in the climatic conditions of interior Alaska, particularly where permafrost exists. Weathering is primarily by freeze-thaw action. Mertie (1937) reported that the total amount of weathering at higher elevations is substantial and produces significant amounts of debris which is transported down the steep headwater valley slopes as colluvium and alluvium.

The headwater drainage systems are overwhelmed and underpowered and cannot easily transport the material downstream. This fluvial incompetence is evidenced in many of the first and second order stream systems, where channels are choked with large sediments. Interfluve areas are well-vegetated and quite stable; hillslope erosion is virtually nonexistent except on roadcuts.

This region escaped continental glaciation during the Pleistocene, but alpine glaciers were present above the 1200 m level. Many of the headwater streams flow through wide, open valleys that are disproportionately large in comparison to their stream channels. Mertie (1937) believed that these underfit streams indicate a long and uninterrupted erosional cycle prior to the Pleistocene, accompanied perhaps by greater precipitation and streamflow.

Mean annual precipitation in the central portion of the basin is 260 mm with 60 to 70 percent of that coming as rain between June and September. Snowfall averages about 130 cm, but the moisture content is quite low. Although precipitation records are not available for the higher elevations in the basin, rainfall and snowfall totals probably increase with elevation. Summers are cool and often rainy, while winters are very cold and relatively dry. A mean annual temperature of -9 C is responsible for the discontinuous permafrost found throughout the region.

A mosaic of vegetation communities has developed within the Birch Creek watershed in response to climate, physiography, surficial geology, soil types, permafrost occurrence, and disturbances such as fire, flooding, and human activity. On the lower slopes, the better-drained sites contain herbaceous plants, mosses, and lichens. Poorly-drained sites are characterized by alder, willow, sedge tussocks, sphagnum, and lichens. The upper slopes support deciduous forests, including birch on silt-loam ridges; black spruce on gentler, colder, poorly drained sites, especially north-facing slopes; and white spruce on the drier south and west-facing slopes.

Riparian communities include white spruce and cottonwood in the lower stream reaches and tall and low shrubs in the upper drainages. White spruce is the climax tree species on floodplains, while the poplar-spruce community may be an intermediate stage. Riparian shrub communities may be tall shrub or low shrub in form. The tall shrub community includes willow thickets and shrub swamps of alder and willow. Low shrub communities may be dwarf birch/ ericaceous shrub bog, mixed shrub/sedge tussock bog, shrub birch/willow, and willow/graminoid bog. Some riparian zones are essentially devoid of vegetation due to placer mining.

Soils are shallow and poorly developed. Permafrost is extensive except on south-facing slopes and in the active channels of perennial streams. Because of these factors, there is little water storage capacity in the soil. The muskeg is several centimeters deep due to the slow rates of decomposition and is capable of storing all the precipitation from smaller storms (Reynolds et al., 1989). Evaporation rates are low and the muskeg may stay moist through- out the summer. This region occasionally experiences large convective storm events that can produce rainfall amounts of 6 cm or greater. Because of its low storage capacity, the Birch Creek watershed, particularly at higher elevations, cannot store rainfall of large magnitude. Prindle (1905) observed that Birch Creek was capable of rising several feet in a few hours following rain and then quickly receding back to normal levels. He attributed this quick hydrologic response to the presence of frozen ground.

Aufeis or valley ice is a phenomenon characteristic of northern latitudes including Interior Alaska. Aufeis is the seasonal accumulation of ice superimposed on the frozen surface of a stream, river, floodplain, or spring (Slaughter, 1990). In response to hydrostatic pressure, water is forced upward through cracks in the existing ice cover and subsequently freezes (Kane, 1981). This process results in very thick ice deposits of large areal extent.

Aufeis can be an important agent in fluvial geomorphic activity if it directs stream energy toward channel formation and enlargement (Slaughter, 1990). Flow capacities may be reduced if large ice volumes occupy the active channels. If the channel is totally occupied by aufeis early in the spring, flow may begin on top of and then gradually erode through the ice. On the other hand, aufeis may play a protective role, dissipating flow energies that would normally be directed at channel banks. According to Mertie (1937), aufeis deposits have the effect of widening valley floors because of the ice acting as a channel obstruction during snowmelt runoff. Flows are either diverted around the ice toward channel banks, initiating lateral erosion, or forced into the channel bed, initiating bed scour (Figure 2).

PROBLEM DEFINITION AND ANALYSIS

The Placer Mining Issue

In a typical modern placer mining operation, crawler-type tractors are used to scrape away the vegetation mat and silt and organic layers that overlay the valley alluvium. Coarser gravels and fractured bedrock that do not contain gold-bearing rocks may also be treated as overburden and piled at the perimeter of the operation. The "pay dirt" (gold-bearing material) is then moved by crawler tractor or front-end loader to the processing plant, where it is screened and sorted to remove larger rocks. A variety of methods are employed to extract the gold from the sorted material. The basic principle, however, is the same for all methods. Since gold has a higher specific gravity than the material it is associated with, gravity and water are utilized to separate and wash the gold particles. Placer gold is sometimes referred to as "free gold" because it is not tied up in an ore complex.

The separation and washing process—commonly called "sluicing"— results in a large quantity of silt- and sand-sized material being discharged from the placer operation. These fine-grained "tailings" traditionally were discharged directly to the stream channel because the mines were located in the valley bottoms close to the placer deposits (Figure 3). Coarser tailings drop out of suspension quickly but the finer particles continue in suspension and are transported downstream. Both inorganic sediments and organic debris may wash into the stream channels as a result of erosion of stripped ground and stored overburden (Reynolds et al., 1989).

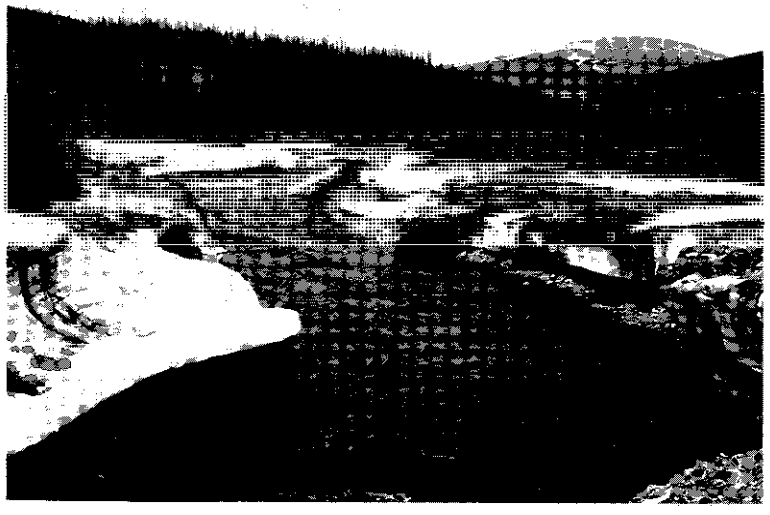

Figure 2. Aufeis influences stream channel morphology and behavior.

Sediment Problems Defined

Placer mining is considered a significant sediment-producing land-use activity (Madison, 1981). Placer mining has been shown to result in an increase in the sedimentation of stream channels (with sediment coming from mine operations as well as from roads); loss of riparian vegetation and associated soils; elimin- ation of stream banks and floodplains, diversion of stream channels; loss of meanders and pools; widening of channels; change in substrate; adverse changes in water quality; depressed aquatic invertebrate populations; and elimination of fish habitat (Weber and Post, 1985; USDI-BLM, 1988). Resuspension of deposited sediments occurs at high flows, but bankfull flows are insufficient for removing fine sediments that settle into gravel substrate. A cementing process was observed to occur on the channel bed (Weber and Post, 1985).

Suspended sediment concentrations and turbidity are key concerns in Birch Creek, a National Wild and Scenic River. Turbidities of only 5 NTU's (nephelometric turbidity units) can decrease the primary productivity of shallow, clear-water interior Alaskan streams. Arctic grayling avoid water having turbidities

Figure 3. A typical placer mine in interior Alaska.

greater than 30 NTU's (Lloyd et al., 1987). Reynolds et al. (1989) and Lloyd et al. (1987) agree that the EPA standard of 5 NTU above natural conditions is reasonable for a high level of protection for stream ecosystems. The State of Alaska has applied effluent performance standards to placer mine operations. The standard for settleable solids is 0.2 ml/L. However, placer mines may discharge water that is still highly turbid even though it meets the settleable solids standard.

Although turbidity may be due in part to the presence of organic material in the water, Lloyd et al. (1987) sampled streams in the Birch Creek drainage and reported that turbidity and suspended sediment concentration were directly related. Reynolds et al. (1989) reported that turbidities in Birch Creek during 1982 and 1983 usually exceeded 1000 NTU, while turbidities in the confluent control stream, Twelvemile Creek, were usually less than 5 NTU. Suspended sediment concentrations averaged greater than 500 mg/L in Birch Creek and less than 100 mg/L in Twelvemile Creek.

Mining and Stream Channel Stability

The regulatory community has been concerned primarily with suspended solids and turbidity issues. Of equal importance is the channel instability that results from traditional mining practices. Sediment overloading leads to aggradation, channel widening wherever banks are erodible, and bar and island development (Heede, 1980). Such channels tend to be laterally unstable (Van Haveren and Jackson, 1986). Extreme channel instability, frequent lateral migration, and an inability to effectively convey upstream inputs of water and sediment are characteristics of these channels (Jackson and Van Haveren, 1984). In extreme cases, channel widening may lead to multiple flood flow channels and braiding (Heede, 1980).

A reach of Birch Creek below a placer mine exhibits many of these instability characteristics (Figure 4). The miner moved the active channel of Birch Creek to a new location in the valley. As Birch Creek cut and formed a new channel, a large quantity of material was transported downstream and deposited at a wide spot in the valley. This local aggradation caused the braiding evident in the photograph.

There are critical thresholds of stream gradient and discharge (or stream power) that if exceeded will convert an alluvial channel from straight to meandering and from meandering to braided. Valley width determines how that stream power is distributed. Thus, valley gradient, valley-floor width, and stream discharge will interact to determine channel pattern or form. According to Schumm and Beathard (1976), thresholds of these variables may be either intrinsic (geomorphic) or extrinsic (dependent on external variables). An example of an extrinsic threshold would be placer mining activity that results in an increase in stream power. Changes in sediment transport capacity will occur with changes in stream power (Phillips, 1989).

A change in sediment type or loading may result in a change in channel morphology and form, followed by a long period of channel instability (Schumm, 1969). Smaller particle sizes have been observed in stream beds below placer mines (Van Haveren, 1989) and greater silt-clay plus sand fractions were found in the bed sediments of mined basins as compared to unmined basins (Van Maanen and Solin, 1988) in interior Alaska.

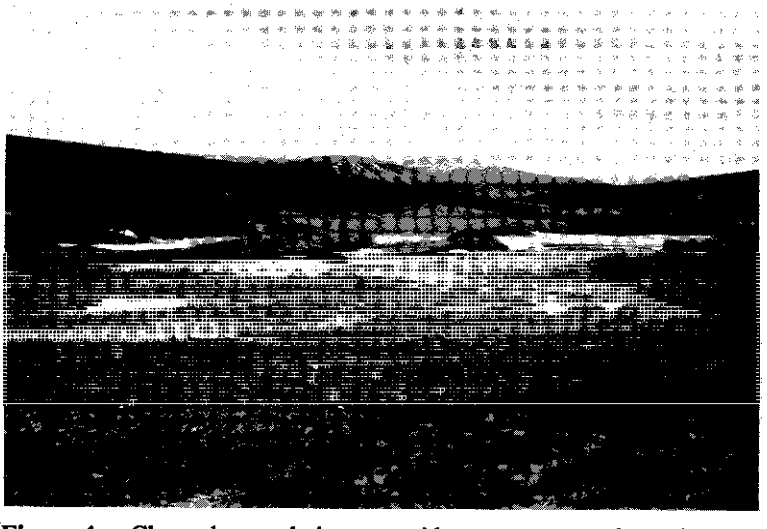

Figure 4. Channel aggradation caused by an upstream channel diversion around a mining operation.

MANAGEMENT IMPLICATIONS

Basin-Wide Approach

Van Haveren (1989) suggested that a basin-wide watershed management approach be used for the Birch Creek watershed. A basin-wide approach is recommended as the appropriate framework within which natural resource conflict

resolution should proceed (Dixon and Easter, 1986). The majority of land in the Birch Creek watershed is Federally-owned and managed by the U. S. Bureau of Land Management. The Bureau of Land Management manages placer mining under the 1872 General Mining Law, which provides for the exploration, development, and production of mineral resources on public lands. Other laws require the Bureau to manage the lands to prevent undue and unnecessary environmental degradation. In addition, the agency is responsible for the management of the Birch Creek National Wild River. The State of Alaska has a responsibility for managing water quality in all surface waters of the state. For example, the U. S. Environmental Protection Agency and the State of Alaska have set turbidity and settleable solids standards, respectively, for mine placer effluent. Although federal and state agencies have similar environmental standards and management goals, the degree of enforcement varies considerably. A greater consistency of enforcement is needed within a basin-wide context.

Mining Impact Mitigation and Rehabilitation

Within a region of similar climate, geology, and land use, hydrologic varia- bles can be correlated with variables which express the geomorphic character of the drainage system (Schumm, 1969). The sensitivity of a given valley and stream system depends on the extent of disturbance, stream power relation- ships, flow resistance characteristics, and the ability of the valley-stream system to distribute and dissipate flow energies. Land-use planning, especially reclamation prescriptions and mining practices, could be based on valley characteristics (Hardy and Associates, 1979). Of particular concern is the potential for significant and long-term stream channel erosion if mined valleys are not stabilized through proper reclamation. Elliott (1989) related valley-floor erosion to three geomorphic variables: drainage area, valley gradient, and valley-floor width. Narrow valleys tend to concentrate water, which increases flow velocities and stream erosive power. Wide valleys have the ability to disperse flow energy. Valley-floor widths in the Birch Creek watershed are a function of drainage area but may also be influenced by local geology, historical erosion and deposition processes, and aufeis formation. The objective of placer-mine rehabilitation should be to first stabilize disturbed upland sites and then to create a new stream equilibrium condition capable of supporting a viable riparian zone (Van Haveren and Jackson, 1986). Rehabilitation prescriptions should be based in part on the relationships between drainage area, valley gradient, and valley-floor width.

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Reservoir Capacity Preserving Practice in Taiwan

Chian Min Wu
Water Resources Planning Commission, MOEA
Taipei, Taiwan

ABSTRACT

The prevailing measures for preserving reservoir capacity in Taiwan are described.In general they can be classified into three categories,i.e.minimizing sediment deposition,maximizing sediment flow through a reservoir, and recovering storage capacity. Recently two of the measures, sluicing by desilting tunnel and evacuation by dredging have been demonstrated to be economically feasible. Hydraulic properties of these measures are elaborated in this paper.

INTRODUCTION

Most major reservoirs in the world are subject to sediment problems of some degree. Reservoir siltation creates major problems in the planning, design and operation of a water resources system. The useful life of a reservoir may be reduced rapidly because of high sediment yield from its drainage basins. The conventional design of a dam and reservoir usually only takes into account the retention of sediment-laden inflow. This results in a rapid decrease in the storage capacity of the reservoir. Thus, in planning, designing or operating a reservoir system, the engineer should further consider the preventive measures to reduce the sediment deposits and to estimate the long-term usable storage capacity to be kept in the future for beneficial purposes of the reservoir operation. In general, these measures may be classified into the following three categories:

1. Measures to minimize sediment deposit in reservoirs.
2. Measures to maximize sediment flow through reservoirs.
3. Measures to recover storage capacity of silted reservoirs.

Being affected by the unfavorable upstream physical conditions the major reservoirs in Taiwan are all subject to sedimentation problems of some degree. Hence, several sedimentation free measures were considered or undertaken in the past. Experiences obtained during past century of reservoir operation will be briefly introduced. Two measures, namely , sluicing by desilting tunnel and evacuation by dredging have been used and demonstrated to be economically feasible means for reservoir sediment removal. These measures illustrated the successful application of hyper-concentrated flow as an aid to either gravitational or mechanical reservoir sediment removal. They are further elaborated herein.

MINIMIZING SEDIMENT DEPOSIT IN RESERVOIRS

Trapping and retaining sediment by a vegetative screen,reducing of sediment inflow by soil conservation, reducing sediement

flow and retaining sediment by check dams,and bypassing sediment-laden flows are considered to be fallen into this category .

Soil conservation in preventing the movement of soil particles or preventing the transport of sediment to the reservoir include agricultural measures like land treatment in the watershed, and engineering measures like watershed structuresin upstream regions.

Agricultural screening, using land treatment measures such as terraced fields,afforestation,grassland,has long been considered to be the most effective measure in preventing the sediment from entering reservoir or lake systems. Such screening measures, either naturally or artificially created at the watershed or head of the reservoir system,serve to filter the incoming flow, reduce the flow velocity and cause the sediment to deposit before it entering the river or reservoir system. Engineering measures considered to reduce the sediment inflow include: stream bank erosion reduction by crib dam drop structures and riprap bank protection; stabilization of landslides by concrete retaining structures and a combination of rock riprap and horizontal drains; reduction of road erosion by culvert installation and improvement and stabilization of road fills, cuts , and gutters by various means. These measures are considered to be standard practice in Taiwan. However,in spite of comprehensive sediment control by soil conservation using these practices in different fields , damages created by sediment deposition are varied and extensive. The coverage of these watershed treatment measures would be large that none of them is considered to be economically justifiable for a basin wide or a subbasin wide application . Furthermore,the effectiveness of such soil conservation practices for large catchment areas can not be estimated with accuracy. In addition to the above mentioned standard practice several other attempts were also tried in Taiwan. These include consolidation of reservoir deposits, construction of large scale check dams, and bypassing of sediment-laden flows by offset reservoirs. They are described below:

Reservoir Bed Consolidation

At the begining of the operation of the Coral Lake Reservoir in 1930,the reservoir was purposely emptied once every four years so that the silt settled in the reservoir bed could be consolidated. The unit weight of the deposited fines might be consolidated from its original state of approximately 410 kg/m^3 to 650 kg/m^3, however, such an increase in unit weight could not easily be predicted geotechnically. Furthermore this type of operation was not considered to be practical to cope with the downstream water demand. Hence,this practice was only tried twice since 1930 .

Large Scale Check Dams

The effects of a check dam on reducing sediment transport are, first, to trap sediment and diminish sediment loads flowing into the reservoir; and second, to raise the bed of the upstream channels and flatten the gully bottom, so that various types of

erosion are controlled or checked. Based on the statistical data, there are more than 850 check dams of different sizes in the upstream areas of 33 major reservoirs in Taiwan . However, their effect might be varied, and from visual observation , the larger the check capacity , the higher the check dam and the higher the checking effect would be . Examples are the check dams in Shihmen Reservoir,i.e. Palin Dam , a check dam of 25.0 -m in height, and Yishing Dam with height of 31.5-m , and Jonghua Dam with height of 81-m. The byproduct of these dams are the hydropower generation .

Offset Reservoirs

Of the different measures adopted in Taiwan, studies showed that offset reservoir with effective diversion intake control is the only solution to the sedimentation problem. To date nine out of the 33 major reservoirs are the offset type. Of which the Sun Moon Lake reservoir, built in 1935, and Coral Lake Reservoir, built in 1930, are representatives .

Generally, most sediment is carried by the river flow during flood periods. If it is possible to construct a reservoir away from the main stream so that during sediment-laden flow periods the flow is returned to the main stream. This will permit a control of the inflow of sediment to the impounding off-set reservoir. The efficiency of bypassing the inflow sediment ,however, is greatly affected by the design and operation of the diversion structures . Of the above mentioned reservoirs, the Sun Moon Lake is comparatively free from sediment problem because of its higher settlement efficiency at the diversion intake area. Table 1 compares the bypassing efficiency of the Sun Moon Lake and Coral Lake Reservoir . The ratio of the average deposit sediment content and the main channel sediment content for Sun Moon Lake Reservoir and the Coral Lake Reservoir is 1:14.2 and 1:2.43, respectively. Apparently the Sun Moon Lake Reservoir has a higher bypassing efficiency of the inflow sediment. However, as a side effect of this bypassing,its diversion dam,Wu-Cheih Dam, a gravity dam of 58 -m high was completely silted up within a six-year period. Thus the benefit of the offset reservoir is achieved at the expense of the diversion intake works.

Table 1. Sediment bypassing efficiency of off-set reservoir

Item	Sun Moon Lake	Coral Lake
Main Watershed area Km^2	501	523
Reservoir Capacity 10^6 m^3	165.4	137.8
Main Channel Discharge 10^6 m^3/yr	1,304.6	1,391.6
Offset discharge 10^6 m^3/yr	644.3	411.5
Annual Sediment Discharge 10^6 m^3	7.18	13.4
Deposit Sediment 10^6 m^3/yr	0.25	1.63
Deposit/Main Flow Sediment	1:28.7	1:8.22
Offset /Main Channel Discharge	1:2.02	1:3.38
Deposit Sediment /Main Channel Sediment content	1:14.2	1:2.43

MAXIMIZING SEDIMENT FLOW THROUGH RESERVOIRS

Maximizing sediment flow through reservoirs can be achieved by increasing the hydraulic gradient of the flow during flood season and releasing as much sediment as possible from the reservoir by making use of the sediment carrying capacity of the floods. Examples are lowering the dam crest or installing deep or bottom outlet facilities.

Increasing Sediment Transport Capacity

Hsinkueishan Dam is one of the typical examples of removing part of the dam structure to increase the sediment transport capacity of a dam system. On the Hsintein River, the reach near Wulai aggraded considerably due to the silting of Hsinkueishan Dam. At 1.8 km upstream from the dam there is a powerhouse named Wulai Power House. Constructed initially in 1941 as a free overflow dam, Hsinkueishan Dam, with overflow crest at El.110 m , has a drainage area of 313 km^2. Backwater extended 2 km upstream including the river reach of Wulai powerhouse to provide sufficient tailwater for the tailrace. In September 1948, a flood inundated the generator floor. In the mean time, the river bed near the tailrace , formed by silting behind the Hsinkueishan dam , was raised from its original elevation of 109.5 to 116.5 m, an increase of 7 m . As a result, the entire tailrace was filled with river deposit.

To cope with the difficulties, the dam crest of the Hsinkueishan Dam was truncated some 7 m lower and the spillway was changed from an ungated to a gated structure in the years between 1949 and 1951 to provide additional storage and regulation. It was assumed that lowering the spillway crest nearly the same amount as the depth of aggradation at the powerhouse, would result in parallel degradation and solve the tailrace problems at the powerhouse. Subsequent operation of the modified gated spillway has verified the expected results. The sediment behind the dam has been flushed out because of the increased sediment carrying capacity of the stream and as a result the river bed at Wulai tailrace has been kept free from the backwater effect of the downstream dam. Similar operation was also performed at Tienlung and Wuchieh Dam.

RECOVERY OF STORAGE

Recovery of storage may be achieved by dredging,flushing of deposited sediment, and siphoning. During the 1950-th siphoning was tested extensively at Gen-Shan-Pei reservoir, however it was concluded that the effective area is localized. In order to increase its efficiency, a flexible pipeline is needed to connect to the bottom sluice . The head part of the pipe is movable so that sediment deposits may be reached and siphoned out by the water head above the outlet.

Dredging

Desilting is an expensive and frustrating operation that involves sluicing and subsequent removal from downstream works or mechanical excavation and disposal. At Shihmen Reservoir the site condition is favorable to dredging. The Shihmen Dam is of an embankment type, 133 meter in height, 360 meters in length, forming a reservoir whose total capacity is 316 $*10^6$ cubic meters. The dam was put into operation in May 1963. However , when the first flood brought about by typhoon Gloria hit the reservoir,the maximum inflow was reported to be 10,200 cms, almost identical to the design spillway capacity of 10,900 cms. In that single flood ,10.5 $*10^6$ cubic meters of sediment was trapped in the reservoir. Succeeding surveys show that the annual rate of siltation has been more than three times as high as that estimated at the time of project design. Afterwards, the intake tower was reconstructed , hundreds of small scale check dams and three high check dams were installed, of which the highest one, Jonghua Dam is 81 meters high with a reservoir capacity of 12.4 * 10^6 cubic meters . In spite of these expensive investments, the silting rate still remained as high as 2.1 $*10^6$ m^3/year. The effect of the sediment deposit was so serious that it even affected the daily operation of the intake tower. Finally, a mechanical excavation and disposal plan was set.

Hydraulic dredger was utilized to remove the deposited materials as deep as 80 meters. A submersible dredge pump with pumping capacity of 900 cubic meters/ hour , a suction head of 25 meters, and power of 170 kw * 10p * 60 Hz was used to draw the deposited materials. The suction head was enhanced with water jetting nozzles of 3.2 m^3/min flow,150 m head, and as a result of the powerful ejecting effect, earth and sand dredged by jetted water were effectively sucked into the suction pipe. The mixture was then pumped ashore by a boost dredge pump with 560 Kw * 4p * 60 Hz power. The dredging was conducted from the seriously affected downstream intake area. Because of the sorting action of the storage reservoir,the materials deposited in this part of the reservoir are mainly fine ones. With the vertical suction method, high dredging capacity was possible and the mud concentration could be up to 30 %. This makes the sediment removal by dredging economically justified. Though, from past five years of prototype operation, the dredging method has been proved to be very powerful in clearing the deposit near the intake area and greatly reduces the burden for reservoir release, the water pollution problem induced by disposal of dredged materials in the downstream channel is extensive. It is an issue that should be addressed in the near future.

Desilting by Sluicing

One solution to the recovery of deposited reservoir capacity is the hydraulic flushing of sediment deposits through low-level sluices. This is a practice that has been successfully applied in Taiwan in the past three decades. Towards the end of the water supply season and before the beginning of the high flow season, a reservoir normally retains some water; this can be used to

desilt the sediment deposits from the previous years. When the desilting sluices are opened, the water level in the reservoir begins to fall, and flow towards the sluices is generated. The reservoir can be flushed by either pressurized condition or free flow condition. Such an operation is being applied for reservoirs with fine or coarse sediments.

Gen-Shan-Pei Reservoir is one of the typical example adopting desilting tunnel with fine sediments. In the southern part of Taiwan there are many watersheds which are characterized by their easily erodable mudstone formation where the sediments are fine in size, uniform in gradation and are easily eroded after saturation. Completed in 1938, Gen-Shan-Pei reservoir is one of the reservoirs located within this region. It is an earth dam 30.0 meters high and 256 meters long with an initial storage capacity of $6.98 * 10^6$ m3 . However, since its initial impoundment it has suffered from severe sedimentation problems. In 1951, prototype operation of the reservoir showed that quite a large amount of deposit materials was desilted through the intake tower. Hence, the proposal of constructing a new desilting tunnel was comprehensively studied in a hydraulic model. A 1:50 scale non-distorted model of the main pocket area was constructed and the most effective means of desilting the reservoir sediments was studied. Froude law was adopted to determine the model scale, and coal powders were used as movable bed materials. The movable bed material was scaled down using the particle fall velocity.It was found that the qualitative behavior of sediment movement near the existing intake area was in good agreement with the prototype . After the completion of the tunnel, three years of prototype experiments were followed. Using the prototype desilting data, the applicability of different sediment transport parameters was studied and several desilting capacity equations were proposed. It was found with the fine sediment deposit hyper-concentrated flow of as high as 45% content can be expected. The proposed equation for the desilting capacity of the sluices was

$$Cw = 847.1\ (V^3/gdw)^{-0.49}$$

or

$$Cw = 369.3\ (Vs/w)^{-0.69}$$

where Cw = the sediment concentration, in kg/m^3
V = the flow velocity in the tunnel, in m/sec
s = the energy gradient of flow in the tunnel
d = the depth of flow in the tunnel, in m
w = the falling velocity of the particle, in m/sec

However,in other parts of Taiwan many rivers are characterized by another extreme composition of coarse sediments ranging from gravel to cobble. Tachia river is one of the typical examples, where a series of dams,from upstream to downstream, Te-chi,Chin-shan,Kukuan and Tien-lun were built. In this series of dams and reservoirs , hydraulic flushing through low-level sluices was applied at Kukuan and Tien-lun Dam. The problems related to their operation are uncertainty of desilting capacity of the sluices , blockage of the gates by sediments and abrasion/erosion of concrete structures. In order to solve these problems hydraulic

models were used and from the model data the desilting capacity of the sluice was obtained as

$$Cw = 0.024\ (V^3/gdw)^{2.66}$$

or

$$Cw = 181.4\ (Vs/w)^{2.54}$$

The difference of desilting equation between the coarse and the fine sediment is considered to be due to the hydraulic properties of the hyper-concentrated flow, however , further studies are needed.

CONCLUSIONS

The experience gained in the last five decades of reservoir operation in Taiwan has been valuable and has cleared many of the misconceptions about the reservoir sedimentation problem. Recently sluicing by desilting tunnels and evacuation of sediment by dredging have demonstrated to have sufficient economic value. Both show the successful applications of hyper-concentrated flow for reservoir desilting either by gravity or mechanical means. With these experiment results at hand it is now possible to have a more realistic assessment of the sediment prevention measures for many reservoirs.

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Benefits and impacts of road removal

TA Switalski[1], JA Bissonette[2], TH DeLuca[3], CH Luce[4], and MA Madej[5]

Road removal is being used to mitigate the physical and ecological impacts of roads and to restore both public and private lands. Although many federal and state agencies and private landowners have created protocols for road removal and priorities for restoration, research has not kept pace with the rate of removal. Some research has been conducted on hydrologic and geomorphic restoration following road removal, but no studies have directly addressed restoring wildlife habitat. Road removal creates a short-term disturbance which may temporarily increase sediment loss. However, long-term monitoring and initial research have shown that road removal reduces chronic erosion and the risk of landslides. We review the hydrologic, geomorphic, and ecological benefits and impacts of three methods of road removal, identify knowledge gaps, and propose questions for future research, which is urgently needed to quantify how effectively road removal restores terrestrial, riparian, and aquatic habitat and other ecosystem processes.

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More than 885 000 km of roads have been built on US federal lands to facilitate resource extraction, recreation, and transportation (Havlick 2002) – enough to drive to the moon and back. While these roads provide important services, their construction and presence can also influence the hydrology, geomorphology, and ecosystem processes. They can substantially alter hillslope hydrology by reducing soil infiltration, concentrating water through road drainage structures, and converting subsurface flow to surface flow (Luce 2002). Overland flow can cause geomorphic changes, including chronic erosion (Megahan and Kidd 1972), extended channel systems (Wemple *et al.* 1996), and increased risk of landslides (Swanson and Dyrness 1975), thereby decreasing aquatic habitat quality. Roads also influence the ecology of terrestrial and aquatic ecosystems through direct habitat loss, fragmentation, and associated human impacts as a result of increased access (Wisdom *et al.* 2000).

Recognition of these wide-ranging effects has recently thrust roads into the forefront of research, resulting in the publication of books (eg Forman *et al.* 2003; Havlick 2002), reviews (eg Gucinski *et al.* 2001; Trombulak and Frissell 2000), special journal issues (eg *Conservation Biology* 14[1], *Earth Surface Processes and Landforms* 26[2 and 3], and *Water Resources Impact* 3[3]), and thousands of peer-reviewed studies. Increasingly, roads are being removed to mitigate these problems. However, to date surprisingly little attention has been given to the short- and long-term benefits and impacts of road removal. Here we describe three methods of road removal, summarize research that has been conducted, and identify knowledge gaps and research needs in this emerging field.

In a nutshell:

- Road removal is being used to mitigate the impacts of roads and restore ecosystem processes
- Preliminary research has found that road removal may temporarily increase sediment loss, but reduce chronic erosion and the risk of landslides over the long term
- More research is needed to determine if aquatic and terrestrial habitats recover following removal

[1]*Wildlands CPR, PO Box 7516, Missoula, MT 59807 (adam@wildlandscpr.org);* [2]*USGS Utah Cooperative Fish and Wildlife Research Unit, Utah State University, Logan, UT 84322-5290;* [3]*Department of Ecosystem and Conservation Sciences, University of Montana, 402 Science Complex, Missoula, MT 59812;* [4]*USDA Forest Service Intermountain Research Station, 316 Myrtle St, Boise, ID 83702;* [5]*USGS Western Ecological Research Center, 1655 Heindon Rd, Arcata, CA 95521*

Road removal

Public and private land managers in the US and Canada are removing roads to restore habitat connectivity and ecosystem processes. For the purposes of this article, we define road removal as "the physical treatment of a roadbed to restore the form and integrity of associated hillslopes, channels, and flood plains and their related hydrologic, geomorphic, and ecological processes and properties". Road removal projects have been undertaken for several reasons: to restrict access, increase hillslope stability, minimize erosion, restore natural drainage patterns, protect endangered plants and wildlife, and restore aquatic and wildlife habitat.

Roads are typically built by using heavy equipment to cut into a hillslope, with extra fill cast aside below the road (Figure 1). Road removal essentially reverses this process. The most common forms of road removal include "ripping" the roadbed, restoring stream crossings, and fully recontouring hillslopes, although a variety of techniques have been applied on the ground (Table 1). Road ripping involves decompacting the road surface to a depth of 30–90 cm, typically done with a bulldozer dragging a specially fitted plow over the roadbed (Figure 2). This is often followed by the addition of soil amendments and by

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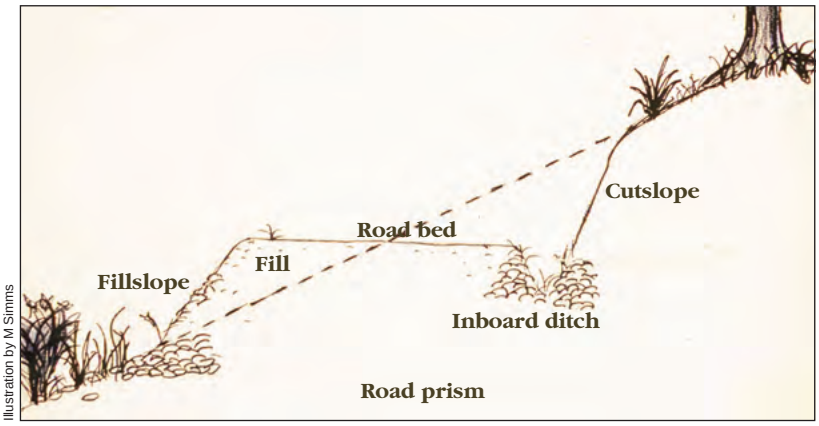

Illustration by M Simms

Figure 1. *Components of a road.*

revegetation. Treatment of stream crossings involves removing culverts, excavating the fill down to the original land surface, recontouring streambanks, installing channel stabilization structures, and revegetating (Figure 3). A full recontour involves treating stream crossings, reshaping the roadbed to its original slope, and revegetating the area (Figures 4 and 5).

Revegetation of the treated road surface is an essential component of habitat restoration, and can include natural regeneration or seeding with native or non-native grasses, nursery-grown trees or shrubs, and transplants from adjacent hillsides. Soil amendments, including sidecast topsoil (soil cast aside during road construction), mulches, biosolids (residual materials from wastewater treatment), and fertilizers are often added to increase nutrient cycling. Sediment control structures such as silt fences, check dams, erosion mats, weirs, rock buttresses, and timber cribs are often employed to reduce surface and channel erosion and the risk of landslides immediately following treatment.

Research review

Road removal is an interdisciplinary endeavor requiring broad expertise, particularly in soils, geology, geomorphology, engineering, hydrology, and ecology. For example, the composition of a soil can greatly influence the degree of water retention and subsurface drainage of a road, and thus the risk of erosion and landslides and the degree of revegetation. In addition, natural environmental factors such as landform features, bedrock type and composition, vegetation, hydrological characteristics, and climate can all have considerable effects on erosion and runoff rates. Although many land management agencies have created protocols outlining methods for road removal, a thorough evaluation of the ability of this procedure to restore hydrologic, geomorphic, and ecological processes has not yet been made.

We have gleaned much of our knowledge on road removal from observational studies and monitoring conducted by land managers in the western US. However, few experimental studies have addressed this topic and few published papers exist. Most studies have occurred in areas characterized by high precipitation, highly erodable soils, and/or steep topography. Additionally, many of the studies have been short in duration and often do not account for long-term variability.

Ripping the roadbed

Roads are compacted initially during construction and later by vehicle traffic. This compaction limits water movement and soil aeration, restricts root growth and elongation, and disrupts nutrient dynamics. In severely compacted soils, infiltration is essentially zero, and establishing vegetation can be difficult (Luce and Cundy 1994). Ripping has been used extensively to increase infiltration and promote revegetation on degraded rangelands (Wight and Siddoway 1972), mined lands (Ashby 1997), and forest skid trails and landings (Davis 1990). On flat and gently sloping landscapes, ripping is the primary method of road removal.

Table 1. Different types of road closure and removal and their relative costs and impacts (modified from Bagley 1998)

Road impact and cost consideration	Gating	Permanent traffic barriers (boulders, berms)	Ripping	Stream crossing restoration	Full recontour
Fill stability problems fixed?	No	No	No	Yes (no if not complemented with recontour)	Yes
Long-term surface erosion controlled?	No	No	Yes	Yes	Yes
Wildlife security improved?	No (yes if gate is able to deter access)	No (yes if barriers deter access)	Yes	Yes	Yes
Cost	$1000–2800	$800–1000	$400–1200/km	$500–150 000 per crossing*	$3000–200 000/km*

*The complexity and variability of stream crossing restoration and full recontour make it easier to compare costs on a per-m^3 basis. The cost of excavating in Redwood National Park ranges from $1–3.50 per m^3.

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Courtesy of S Moore

Figure 2. *Ripping the roadbed, Pueblo Mountain Wilderness Study Area, OR.*

Courtesy of T Brow

Figure 3. *Stream crossing restoration, Clearwater National Forest, ID.*

Studies on road ripping have been carried out in diverse landscapes across North America, in a variety of ecotypes; this procedure has been found to reduce erosion, improve infiltration, increase the rate of revegetation, and discourage weed establishment (defined as nonnative invasive species).

Infiltration and erosion

Road ripping increases infiltration and reduces erosion in the short term, but has produced mixed results in the long term. In the boreal forests of west-central Alberta, Canada, ripping substantially reduced bulk density (the mass of dry soil relative to volume) immediately following treatment (McNabb 1994). In western Montana, Bradley (1997) found that ripping successfully improved infiltration rates 3 months after treatment. Following a 12-year return interval storm, Bloom (1998) concluded that ripping greatly reduced landslide erosion on low-risk terrain in northern California.

Other studies, however, report that ripping alone has marginal long-term success. Luce (1997) reported that hydraulic conductivity (a measure for comparing infiltration capacity) increased immediately following the ripping of Idaho logging roads, but a number of the roads returned to their original bulk densities after three simulated rainfall events. Soil texture determined the success of the treatment: soils high in fine silts and clays underwent surface sealing, while soil settlement occurred in sandier, granitic soils. Although straw mulch could be used to treat surface sealing, it had no effect on soil settlement (Luce 1997). In western Montana, however, Bradley (1997) found mulch prepared from slash (forest harvest residues) mitigated surface sealing successfully.

Revegetation and weed invasion

Quickly establishing vegetation is a priority for any road removal project. Vegetation is one of the first visual signs of ecosystem recovery, and creates habitat for a variety of animals. Ripping the road surface loosens soil and increases infiltration capacity, improving the germination and growth of seeded plants (Wright and Blaser 1981). The resulting vegetative cover further protects against erosion and maintains infiltration capacity. Revegetation studies tested the effectiveness of different seeding techniques and measured revegetation trends over time. While results varied, incorporating soil amendments generally increased rates of revegetation.

Road sites are typically nutrient poor, and the addition of organic matter to a ripped roadbed can greatly accelerate the establishment of vegetation. Applying straw mulch decreased erosion and increased the rate of revegetation in northern California (Hektner and Reed 1991) and north-central Idaho (Stonesifer and McGowan 1999). Incorporating biosolids, an amendment rich in

Figure 4. *Results of full recontour, Lolo National Forest, MT.*

Figure 5. *Full recontour, Clearwater National Forest, ID.*

nutrients and organic matter, significantly increased total vegetative cover and native plant biomass on treated roadbeds in western Washington after 3 years of monitoring (Bergeron 2003). Incorporating topsoil to a ripped roadbed increased natural revegetation in northwestern Wyoming (Cotts *et al.* 1991) and northern California (Hektner and Reed 1991). However, in northern Arizona neither topsoil nor mulch increased total plant density or cover after 14 months (Elseroad *et al.* 2003). Bradley (1997) found that lopped slash combined with fertilizer yielded healthy grass communities in northwestern Montana after 12 weeks, but the effects of fertilizer may be short-lived. For example, on restored roadbeds in Connecticut, fertilizer only improved vegetation growth in the first year after application (Maynard and Hill 1992).

While road ripping has been shown to increase the rate of revegetation, it may create conditions conducive to weed invasion. Furthermore, soil amendments may supply higher than normal levels of nitrogen, accelerating revegetation but favoring weeds (Zabinski *et al.* 2002). Monitoring and preliminary research, however, suggest that ripping may actually reduce the risk of invasions, because native vegetation is able to out-compete weeds and because ripping eliminates a primary vector (human access) for further invasions. Moreover, locations with higher precipitation recover faster and are less susceptible to weed invasion. In northern California, some weeds emerged following treatment and natural revegetation on hot dry terrain, but very few weeds appeared in moister areas (Madej *et al.* 2001). Monitoring in the lush forests of north-central Idaho revealed few weeds following treatments (USFS 2003). Bradley (1997) also found that weed invasion was generally reduced following ripping in wet sites in western Montana.

Restoring stream crossings

Where roads intersect streams, there is the potential for large amounts of sediment to be released into the stream system. If a culvert is plugged with debris, the result is often a washout where the streamflow overtops the road and erodes to the original stream grade. These washouts can then cause other downstream culverts to fail in a domino effect. When a blocked culvert does not result in a local washout, streamflow may be diverted down the roadbed itself or along the slope-side ditch, causing large amounts of gully erosion along the roadbed and hill slopes below the road. For example, in northern California, Best *et al.* (1995) recorded that only 15 stream diversions produced 64 000 mt of sediment (about 4000 dump trucks' worth) over a 25-year period.

Stream crossing restoration has been used in many areas in an effort to reduce the risk of catastrophic washouts and associated impacts on aquatic ecosystems. Most stream erosion occurs during times of high streamflow, and the effectiveness of stream crossing restoration was typically measured after a major flood event. There is potential for local erosion immediately after the excavation of a stream crossing, but this can be partially mitigated by using sediment traps – often straw bales placed in streams to catch sediment (Brown 2002). The impacts of short-term sediment loss on aquatic biota have not been evaluated yet. Channel incision and bank erosion were the most common forms of stream erosion reported, and were correlated with stream power (velocity of water flow), the amount of large wood in channels, the percentage of coarse material in stream bank soils, the amount of road fill excavated, and local geology.

Klein (1987) monitored channel adjustments on 24 stream crossings in Redwood National Park, CA following a 5-year return interval flood. Erosion was correlated with stream power and inversely correlated with the percentage of large wood in the channel and coarse material in streambanks. Following a 12-year return interval storm in 1997, two researchers revisited the impacts of stream crossing restoration in Redwood National Park. Madej (2001) examined 207 stream crossings treated between 1980 and 1997, and found that most treated crossings produced very little sediment and none resulted in diversions or debris torrents (rapid movement of large quantities of materials downstream) (Table 2). The amount of sediment eroded was positively correlated with stream power, but was also correlated with the size of the stream crossing (Madej 2001). After surveying 86 treated stream crossings, Bloom (1998) found that only four crossings contributed substantial erosion (>37 m^3). Five to 20 years after culvert removals, pool habitat

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in excavated streams had only partially recovered (Madej 2001b), but a riparian zone of young red alder (*Alnus rubra*) was providing a closed canopy and shade over the streams (Madej *et al.* 2001).

Full road recontour

Landslides

If a roadbed on a steep slope becomes saturated, there is an increased risk of road-triggered landslides. Full road recontour, the most intensive form of road removal, includes treatment of the road segments between stream crossings, and is often employed to reduce the risk of landslides. Most landslides occur during periods of high rainfall and, like stream crossing restoration, the success of the treatments are gauged following a flood event. Full road recontour has been used effectively to reduce landslides in northern California (Bloom 1998; Madej 2001), western Washington (Harr and Nichols 1993), coastal Oregon (Cloyd and Musser 1997), and north-central Idaho (McClelland *et al.* 1997; USFS 2003). Important factors determining the risk of failure following treatment include hillslope position and history of landslides.

In Redwood National Park, where full recontour was first introduced, a 12-year return interval storm in 1997 provided the opportunity to measure the effectiveness of two decades of road removal. Most treated roads produced very little sediment. Eighty percent of the road reaches had no detectable (> 2 m^3) landslide erosion following treatment (Madej 2001). Untreated roads produced four times as much erosion as treated roads, mostly in the form of landslides (Bloom 1998; Madej 2001; Figure 6). Both Bloom (1998) and Madej (2001) reported that hillslope position (as a surrogate for hillslope steepness and the amount of surface and subsurface water present) was an important factor in determining treatment success. Although treatments dramatically reduced sediment loss from upper- and middle-slope roads (< 40% gradient), steep lower-slope roads continued to have high failure rates, no matter what treatments were used.

The Clearwater National Forest in north-central Idaho experienced a 50-year return interval flood in the winter of 1995/1996. A rain-on-snow event triggered more than 900 landslides on highly erodible granitic soils, half of which were attributed to roads (McClelland *et al.* 1997). Ten kilometers of roads were recontoured prior to the storm. Although ten landslides would have been predicted in McClelland's model prior to recontouring, no landslides occurred on the treated roads (McClelland *et al.* 1997). To date, over 700 km of roads have been removed from this forest with only seven landslides observed, four of which were in areas of historic or pre-existing landslides (USFS 2003). However, the Clearwater has not experienced a serious flood event since then, and a further test of the effectiveness of the road treatments has not occurred.

Chronic erosion

Although most full road recontour studies have only examined landslide events following floods, the reduction of chronic erosion is also a goal of many road removal projects. Chronic erosion from roads can greatly reduce an aquatic system's integrity, and in some cases can be the sole source of sediment input. A short-term problem with road removal is that following a road

Table 2. Sediment loss on treated and untreated stream crossings in northern California

Treated or untreated	Hillslope position	Mean (median) erosion rate (m^3)*	Mean percentage (median) of excavated fill	Storm recurrence interval (yrs)	Source
Treated	All	27 (11)	–	5	Klein (1987)
Treated	Lower	97 (69)	11 (5)	12	Bloom (1998)
Treated	Middle/upper	79 (11)	10 (1)	12	Bloom (1998)
Treated	All	50 (17)	8 (3)	12	Madej (2001)
Treated	All	15	2	2–5	Pacific Watershed Associates (unpublished)
Treated	All	42 (4)	3 (1)	2–5	Six Rivers National Forest (unpublished)
Untreated	Lower	115	–	12	Bloom (1998)
Untreated	Middle/upper	180	_	12	Bloom (1998)
Untreated	All	235	_	50	Best *et al.* (1995)

*Many studies only report mean values for erosion, but because crossing erosion volumes are not normally distributed (commonly there are a few extreme values), median values of erosion may be a more useful indicator of expected erosion in a crossing.

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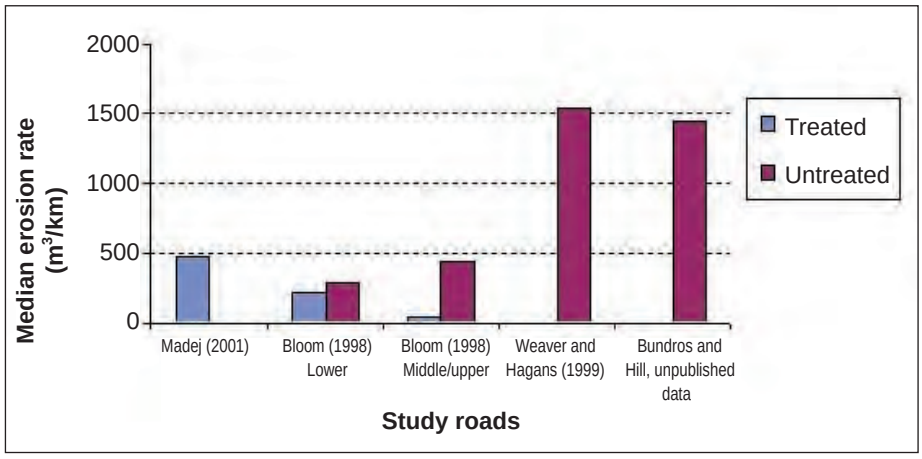

Figure 6. *Sediment loss on treated and untreated roads in northern California. Values from Bloom do not include sediment loss from stream crossings on these roads (reported in Table 2), whereas the other studies include stream crossing erosion as part of the sediment loss.*

recontour, the bare slopes are very susceptible to erosion. As the slope becomes revegetated over time, however, erosion levels eventually mimic natural slope conditions.

Hickenbottom (2000) showed that recently recontoured road segments produced significantly ($P < 0.05$) more sediment than road segments recontoured 12 months prior to analysis. Average sediment yield was 746 g/m^2 for recently recontoured roads (versus 402, 62, and 26 g/m^2 for the untreated roads, 12-month-old recontour, and control plots, respectively). These values are derived across five replicate plots for each treatment type applied across two geologic strata and three slope classes; however, the analyses were all performed within one watershed. Although these numbers demonstrate a great reduction of sediment yield just one year after recontouring, recontoured roads are susceptible to erosion immediately following treatment. Similarly, in north-central Idaho after 5 years of monitoring, the Clearwater National Forest reported that road treatment has eliminated surface erosion outside of treated stream crossings (USFS 2003). Additionally, in fully recontoured roads in eastern Kentucky, there was considerably less sediment produced than in untreated control plots after one growing season (Kolka and Smidt 2001).

Influence on wildlife

One of the many goals of road removal is the restoration of the ecological integrity of terrestrial, riparian, and aquatic habitats. In addition to preservation of habitat, restoration may be essential to maintaining and increasing biodiversity (Sinclair *et al.* 1995). Virtually no research has addressed the impact of road removal on wildlife. Since terrestrial wildlife is greatly influenced by road density (Wisdom *et al.* 2000), it is likely that road removal may also affect wildlife.

Roads influence wildlife in a variety of ways, including reduced numbers of snags and downed logs; altered movement patterns; increased negative edge effects; and increased poaching, hunting, trapping, and additional negative interactions with humans facilitated by easier access, including direct mortality from car collisions (Wisdom *et al.* 2000). Removed and revegetated roads would presumably reverse many of these impacts and create habitat for a variety of animals. Bradley (1997) found Western toads (*Bufo boreas*) on ripped roads in western Montana, where slash created structural diversity and microhabitats. Some wildlife biologists argue that road removal will reduce grizzly bear (*Ursus arctos*) mortality risk (USFWS 1993) and increase elk (*Cervus elaphus*) habitat security.

Roads can greatly impact aquatic systems in complex ways, including blocking fish passages, introducing fine sediment and non-native species, changing amounts of shading and cover, direct channel infringement, and increasing access and predation by anglers (Luce *et al.* 2001). A reduction in sediment delivered to streams should increase the quality of aquatic habitat. For example, suspended sediments can negatively impact salmonid fisheries through direct mortality, hindering the development of eggs and larvae, disrupting natural movements and migration, reducing food organisms (Newcombe and MacDonald 1991), and hindering fish feeding behavior through reduced visibility. (In contrast, inboard ditches can serve as habitat for amphibians and benthic macroinvertebrates, and road removal decreases the amount of this habitat). There is an urgent need for research that specifically addresses the ecological impact of road removal on aquatic, riparian, and terrestrial habitats.

Prioritization

With limited budgets and hundreds of thousands of kilometers of roads, it is essential that land managers prioritize road removal efforts. The process of prioritizing road removal is complex and must take into account ecological, economic, and social costs (Luce *et al.* 2001). Most projects prioritize "problem" roads that contribute large amounts of sediment to streams, reducing the quality of fish habitat. Many road removal projects in the Rocky Mountains have prioritized roads that allow for habitat security for grizzly bears and elk.

An ecologically relevant prioritization approach might attempt to increase the amount of highest quality habitat within watersheds. Selecting roads that affect large reaches of streams or watersheds with already low road densities may be most appropriate. Although handbooks, peer-reviewed articles, and workshops have addressed the issue of prioritization, no comprehensive protocol exists,

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and field units still commonly apply an ad hoc process for selecting roads to be removed. Better prioritization practices are at least as important as improvements to rehabilitation techniques.

Future research questions

While some research has been conducted on the effectiveness of road removal, there are still large gaps in our knowledge. It is imperative that we support any restoration efforts with sound science. Baseline data are important, as is meta-analysis (an overview analysis of many studies) of similar projects to predict expected outcomes. Monitoring after intervention is essential to understanding the long-term dynamics, as is replication in different soil types and climates. The effectiveness of a particular approach depends on the context (eg soils, climate, and topography) of the treatment. Addressing the impacts of road removal at different spatial scales would also be very helpful.

If the restoration of ecosystem processes is the goal of road removal, then it is also essential that we document ecosystem recovery and modify our mitigation as appropriate. The reduction of erosion and increased infiltration following road removal has been documented (eg Luce 1997; Madej 2001) and continued research on hydrologic and geomorphic restoration will soon allow meta-analysis. However, the effectiveness of restoring natural stream and flood plain function still needs to be addressed. Finally, one of the most important research tasks ahead is quantifying the benefits of road removal on aquatic, riparian, and terrestrial ecosystems. No studies have yet examined the influence of road removal on the recovery of these ecosystems. Although road removal is now ocurring across the US and parts of Canada, a rigorous evaluation of 20 years of restoration in northern California by an interdisciplinary team of experts could be an eminently fundable and important project.

Conclusions

Even after thousands of kilometers of roads have been removed, there is an alarming lack of published analysis of the effectiveness of these efforts. Road removal creates short-term disturbances that can temporarily increase sediment loss, but in the long-term, road removal may reduce chronic erosion and the risk of landslides. Continued research is greatly needed, especially quantifying how effective various road removal techniques are in restoring terrestrial, riparian, and aquatic habitat. As is often the case, however, the best solution is prevention. In northern California, on steep lower slope roads, no form of road removal was able to prevent chronic erosion completely. Increased research on this emerging field will help us more effectively remove roads, set restoration priorities, and ultimately help restore the integrity of entire ecosystems.

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Revision of widespread red squirrels (genus: *Tamiasciurus*) highlights the complexity of speciation within North American forests

Andrew G. Hope [a,*], Jason L. Malaney [b], Kayce C. Bell [c], Fernando Salazar-Miralles [c], Andreas S. Chavez [d], Brian R. Barber [e], Joseph A. Cook [c]

[a] Division of Biology, Kansas State University, Manhattan, KS 66506, USA
[b] Department of Biology, Austin Peay State University, Clarksville, TN 37044, USA
[c] Department of Biology and Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM 87131, USA
[d] Museum of Vertebrate Zoology and Department of Integrative Biology, University of California-Berkeley, Berkeley, CA 94720, USA
[e] Biodiversity Institute, University of Wyoming, Laramie, WY 82071, USA

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ABSTRACT

Integration of molecular methods, ecological modeling, and statistical hypothesis testing are increasing our understanding of differentiation within species and phylogenetic relationships among species by revealing environmental connections to evolutionary processes. Within mammals, novel diversity is being discovered and characterized as more complete geographic sampling is coupled with newer multi-disciplinary approaches. North American red squirrels exemplify a forest obligate genus whose species are monitored as indicators of forest ecosystem condition, yet phylogenetic relationships reflecting evolutionary history within this genus remain tentative. Through testing of competing systematic and niche-based divergence hypotheses, we recognize three species, *Tamiasciurus douglasii*, *T. hudsonicus*, and *T. fremonti*. Our data provide evidence of regional differences in evolutionary dynamics and continental gradients of complexity that are important both for future management and for investigating multiple pathways that can lead to the formation of new species.

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1. Introduction

Understanding how the formation of species is shaped by common biogeographic and evolutionary processes (Hewitt, 2000; Taberlet et al., 1998) is a critical step for recognizing and conserving biodiversity (Riddle et al., 2008; Whittaker et al., 2005). Range-wide evolutionary assessments of species that incorporate both genetic and niche-based approaches provide critical perspectives on regional evolutionary and ecological differences in biodiversity. For instance, many vertebrate species associated with the boreal biome in North America have broad continent-wide distributions coincident with temperate and northern conifer forests (Arbogast and Kenagy, 2001), but these forests are now experiencing increased mortality (Allen et al., 2015), and regional declines (Coops and Waring, 2011; Gauthier et al., 2015) will likely continue to impact vertebrate communities. Geography and past climate have shaped the assembly of communities according to predictable biogeographic patterns that often reflect common evolutionary processes (Hampe and Petit, 2005). Northernmost contemporary populations frequently constitute a leading edge of expansion due to climate warming following the Last Glacial Maximum (LGM; ~the last 12 kyrs). However, high-latitude populations may have also experienced spatial and temporal stability if they persisted through the Last Glacial period (~130–12 ka) within one or more northern refugia (Brubaker et al., 2005; Hewitt, 1999; Lessa et al., 2003). Mid-latitude forest-associated populations often have multiple distinct lineages distributed longitudinally across the continent reflecting repeated isolation in discrete areas south of glacial-phase continental ice-sheets. However, the genetic signatures of independent histories among these lineages are often obscured at their distributional edges where they now overlap geographically (Atkinson et al., 2007; Hope et al., 2014a). Signatures of these complex histories of isolation and reconnection are often apparent along contact zones (Swenson and Howard, 2005) where dynamics of gene flow and interspecific interactions result in increased community complexity (Hewitt, 2000). Finally, peripherally isolated populations in southern and coastal regions

* Corresponding author at: Kansas State University, Division of Biology, 116 Ackert Hall, Manhattan, KS 66547, USA.
E-mail addresses: ahope@ksu.edu (A.G. Hope), jmalaney@gmail.com (J.L. Malaney), kayce.bell@gmail.com (K.C. Bell), f.salazarmiralles@gmail.com (F. Salazar-Miralles), aschavez@berkeley.edu (A.S. Chavez), bbarber4@uwyo.edu (B.R. Barber), cookjose@unm.edu (J.A. Cook).

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generally occur in patches of discontinuous forest. Peripheral populations can reflect either long-term isolation (⩾1 glacial phase; e.g., Cook et al., 2001, 2006) or more recent fragmentation of previously continuous habitat since the LGM (Galbreath et al., 2009). Such isolates often constitute important sources of genetic diversity for species (Channell and Lomolino, 2000) with high conservation value (Malaney and Cook, 2013).

A growing body of comparative genetic evidence indicates that evolutionary processes of diversification on a continental scale are repeatable both across taxonomic groups and through time, where cryptic diversity is discovered as additional groups are assessed, resulting in recognition of new species, or minimally, distinct evolutionary lineages (Hope et al., 2014a). Given that species descriptions are ongoing, even among mammals, current taxonomy frequently fails to adequately reflect the extent of evolutionary diversity or relationships among extant lineages (Patterson, 2000; Bickford et al., 2007), thus impeding effective management and conservation of fundamental components of biodiversity (Soltis and Gitzendanner, 1999; Hoberg et al., 2012). New toolsets are facilitating species discovery based on multi-locus sequence data (Knowles and Carstens, 2007). Concurrently, new statistical methods assess "species" limits, recognizing taxonomic or systematic arrangements that hold strongest support for actual relationships among distinct biological units (reviewed in Carstens et al., 2013). Both historical and ongoing gene flow between related species (e.g., Sullivan et al., 2014), however, present additional challenges to molecular systematic assessments.

The evolutionary history of North American red squirrels (genus *Tamiasciurus* Trouessart 1880) reflects the influence of long-term Quaternary climate cycles on continental patterns of diversification and community change (Arbogast and Kenagy, 2001). Periodic allopatry and divergence has been followed by episodes of reconnection and gene flow as climate cycled through glacial phases (Chavez et al., 2014). Simultaneously, some red squirrel populations, particularly peripheral ones, likely remained stable and isolated through extended glacial cycles. As such, systematic relationships, species limits, and taxonomy within this group remain tentative. Thorington and Hoffmann (2005) recognized three species: *Tamiasciurus douglasii* Bachman, 1839, distributed in forests from southern California and the Sierra Nevada northward through the Cascade and Coastal ranges; *Tamiasciurus hudsonicus* Erxleben, 1777, distributed across most of North America north of Mexico including multiple peripheral populations; and *Tamiasciurus mearnsi* Townsend, 1897, restricted within Baja California Norte, Mexico. Previous mitochondrial DNA (mtDNA) assessments (Arbogast et al., 2001; Barber, 2007) documented several divergent lineages, recounting a complex biogeographic history. Across these species, *T. hudsonicus* is paraphyletic with respect to *T. douglasii*, while *T. mearnsi* is minimally divergent from *T. douglasii* (Arbogast et al., 2001; Barber, 2007). In the American Southwest, populations of *T. hudsonicus*, including those on sky islands, potentially represent a third species (*Tamiasciurus fremonti*), based on genetic (Arbogast et al., 2001), behavioral, and morphological differences (Findley, 1961; Hardy, 1950). More recently, Chavez et al. (2014) largely corroborated these relationships with nuclear data, although mito-nuclear discord indicated historic introgression between populations of the Pacific Northwest. However, to date, no study has explicitly tested the validity of systematic relationships using a phylogenetic approach.

The North American red squirrel complex constitutes an excellent system for testing diversification hypotheses because their complex biogeographic history includes both physical (insular) and ecogeographic isolation of lineages, paraphyly, and gene flow. We present a multi-locus phylogenetic assessment of North American red squirrels and test three alternative hypotheses based on previous studies (Fig. S1). In the first hypothesis (H1 – Fig. 1) we apply the current taxonomy (Thorington and Hoffmann, 2005) of three species (*T. douglasii, T. hudsonicus,* and *T. mearnsi*). Considering that the specific status of *T. mearnsi* is tenuous (Arbogast et al., 2001), we test a second hypothesis (H2 – Fig. 2) proposed by Arbogast et al. (2001) that also posits three differently circumscribed species: *T. douglasii* (inclusive of *T. mearnsi*), *T. fremonti*, and *T. hudsonicus* (includes all currently recognized lineages except putative *T. fremonti*). Finally, we consider a third hypothesis (H3 – Fig. 3) treating nine well-supported mtDNA lineages as terminal taxa, all documented across independent studies (Arbogast et al., 2001; Barber, 2007; Chavez et al., 2014; this study). These three hypotheses require few assumptions and reflect realistic alternative relationships based on previous literature. Following genetic-based species delimitation, we incorporate niche modeling to assess geographic stability through time and ecological divergence among taxa. Finally, we use results from both multiple loci and climatic data to explore evolutionary complexity across North America, demonstrating different modes of speciation within this complex that are reflected more broadly among mammals. Critically, for forest ecosystem management, we identify areas that sustain key dynamic evolutionary processes as well as isolated populations needing further evaluation.

2. Methods

2.1. Study area, sampling and sequencing

We obtained specimens from museum collections that maximize geographic sampling through the known range of red squirrels (Figs. 1 and 3), including samples from all species and localities coincident with the geographic distribution of 22 of 28 subspecies (Hall, 1981). We used 252 specimens (Appendix A) including 40 *T. douglasii*, 209 *T. hudsonicus*, and 3 *T. mearnsi* from 109 general collecting localities (Fig. 3; 153 specific localities; Appendix A). Sequences for 123 individuals for at least 1 gene were retrieved from GenBank. We then sequenced 129 more specimens for 1–4 independent loci where a subset of 60 samples (including 34 specimens from Chavez et al., 2014) were represented by both mtDNA and nuDNA. In total we obtained 3192 bp of sequence data across all loci. Datasets included 771 base pairs (bp) of mtDNA cytochrome-*b* gene (Cytb; $n = 252$), 449 bp of the glutamate decarboxylase 2 gene (intron 1; GAD2; $n = 60$), 666 bp of the ganglioside-induced differentiation-associated protein 1 gene (intron 1; GDAP1; $n = 58$), 630 bp of the UPF0351 protein C9orf32 gene (intron 1; METTL11A; $n = 59$), and 676 bp of the prolyl 4-hydroxylase alpha-2 subunit precursor gene (intron 1; P4HA2; $n = 60$).

We extracted genomic DNA from tissue (stored at −80 °C or ethanol preserved) through standard salt extraction, followed by PCR amplification and cycle sequencing with ABI BigDye v3.1 (Applied Biosystems, Foster City, California) following protocols of Platt et al. (2007). Primers for Cytb were MVZ05/MVZ16 (Smith and Patton, 1993). Other primers are listed in Chavez et al. (2014). We conducted automated sequencing of complimentary strands using the Applied Biosystems 3110 DNA sequencer at the University of New Mexico.

We edited and aligned sequences in Sequencher v4.8 (Genecodes, Ann Arbor, Michigan) and verified visually. We translated protein-coding sequences for Cytb to amino acids and examined them for internal stop codons, rates of transition/transversion changes, and relative 1st, 2nd, and 3rd position changes in codons that might indicate a Numt. None was found. We compared complementary strands of DNA and deposited contiguous sequences in GenBank (Appendix A). We inferred alleles of heterozygotes using Phase (Stephens et al., 2001), by accepting results with a

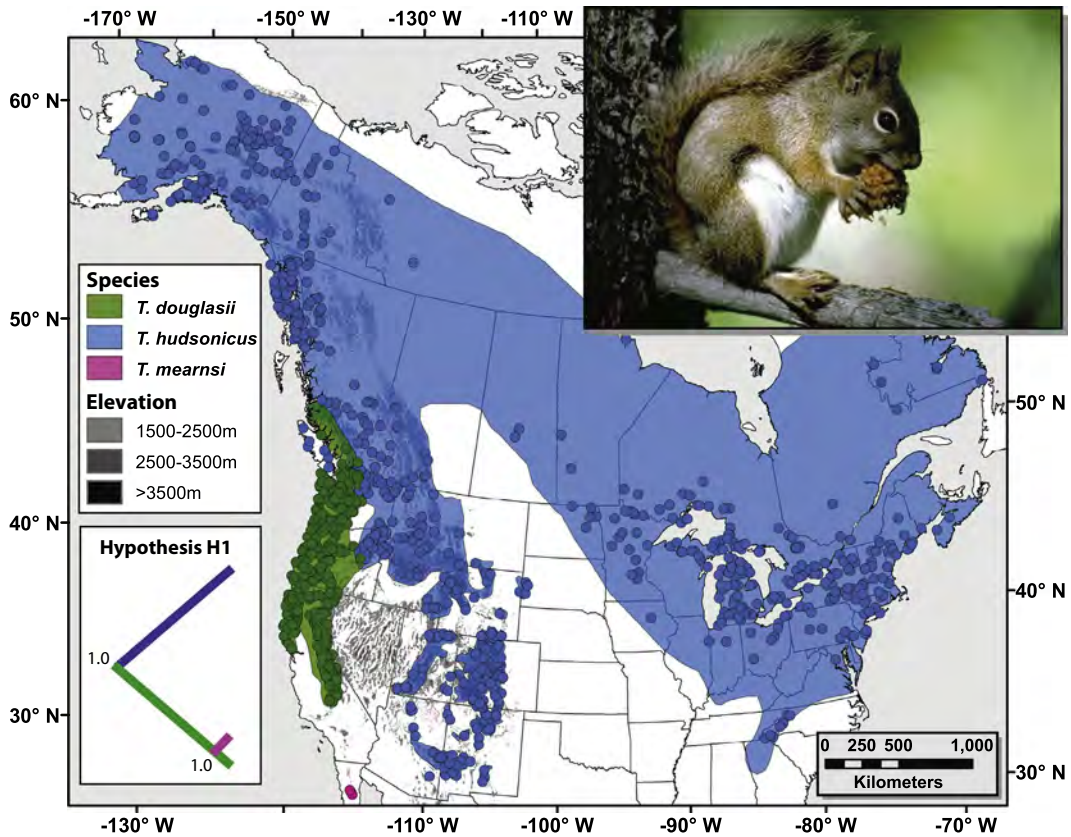

Fig. 1. Distribution and current taxonomy of North American tree squirrels (*Tamiasciurus*). Data points indicate localities of all samples considered for niche analyses. Inset provides the results of a *BEAST species tree analysis (including empirical topology and nodal support values) considering systematic hypothesis H1 with three species as *T. hudsonicus*, *T. douglasii*, and *T. mearnsi*. Downloaded from Wikipedia March 2015. Author: Cephas. This file is licensed under the Creative Commons Attribution-Share Alike 3.0. Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled *GNU Free Documentation License*.

probability >90%, using a burn-in of 10,000 iterations and a run length of 10,000 iterations (McCormack et al., 2011). Among 5 runs, we retained results from the run with best goodness-of-fit to an approximate coalescent model, resulting in 2 nuclear haplotype sequences or alleles per individual, using only 1 allele per individual (chosen randomly) for analyses.

2.2. Multi-locus gene trees and evolutionary rates

We estimated independent genealogies and haplotype networks for all loci. We determined DNA substitution models for each locus using MrModeltest v2.3 (Nylander, 2004) under the Akaike Information Criterion. We performed Markov chain Monte Carlo (MCMC) searches in MrBayes v3.1 (Ronquist and Huelsenbeck, 2003), incorporating the short-branch method (Marshall, 2010). Stationarity of MCMC runs was assessed in Tracer v1.5.0 (Rambaut and Drummond, 2007). Phylograms were midpoint rooted and visualized with posterior probabilities >0.75 included in FigTree v1.3.1 (Rambaut, 2009). For all loci, we assigned haplotypes using DnaSP v5 (Librado and Rozas, 2009). Median-joining haplotype networks for all loci were constructed in Network v4.610 (Bandelt et al., 1999). To assess the timing of cladogenesis and demographic changes among lineages, we calculated average and lineage-specific evolutionary substitution rates utilizing a time to coalescence of the entire genus as estimated by Chavez et al. (2014). In BEAST v1.6.1 (Drummond and Rambaut, 2007), we produced a chronogram based on the Cytb locus by fixing the time to most recent common ancestor (T_{MRCA}) for all samples at 0.4229 Ma (normal distribution, standard deviation 0.1; Chavez et al., 2014), applying a relaxed clock: uncorrelated log-normal, and set the substitution rate to be estimated. We used the HKY + G model of substitution, empirical base frequencies, partitioned into three codon positions, and a constant population size tree prior. Three separate runs of 100 million iterations were run, sampling trees to file every 1000 iterations. To retrieve mean lineage-specific rates for each nominal lineage recovered from the Cytb chronogram, we weighted all branch specific rates by branch length (Hope et al., 2014b) according to the equation $\sum$ (rate $\times$ length)/$\sum$ (length).

2.3. Mitochondrial diversity and demographics

Genetic diversity analyses for Cytb used all available red squirrel sequences, performing analyses separately for major lineage assignments (Table 1). In DnaSP, for each group we assessed genetic diversity including number of segregating sites (S), haplotypes (h), haplotype diversity (Hd), nucleotide diversity (π), and tested for demographic expansion by calculating Tajima's D (Tajima, 1989) and $R2$ (Ramos-Onsins and Rozas, 2002).

To calculate population size change through time, we implemented the coalescent Bayesian Skyline Plot (BSP) tree prior in BEAST. Results of Bayes factor tests to determine the best clock model indicated no significant difference between strict and relaxed clocks for any lineage, so we utilized a strict clock, and ran MCMC analyses (length of chain = 100 M logging trees every

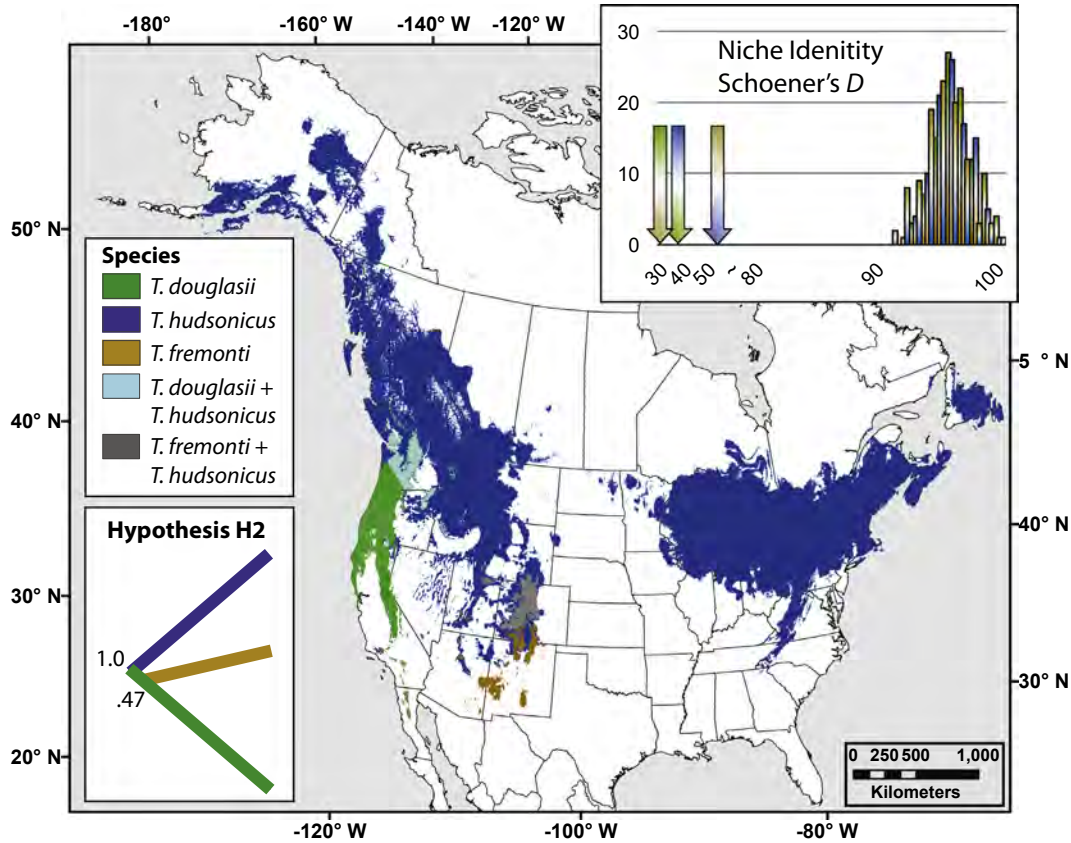

Fig. 2. Bioclimatic envelope models for North American red squirrels considering three species according to systematic hypothesis H2 as *T. douglasii* (green), *T. fremonti* (brown), and *T. hudsonicus* (dark blue). We used model selection and applied a minimum of 90% of training samples as our threshold for each species. Potential geographic overlap between species is depicted with intermediate colors (cyan between *T. hudsonicus* and *T. douglasii*, and gray between *T. hudsonicus* and *T. fremonti*). Left inset provides the results of *BEAST species tree analysis considering H2, including empirical topology and nodal support values. Top inset shows results of niche identity test, where all pairwise comparisons indicate significant ecological differentiation between species. The histogram provides expected niche overlap when pairwise species are pooled and randomized, and arrows indicate empirical niche overlap between species (Schoener's *D*). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

1000), assigning lineage-specific rates calculated from the Cytb chronogram.

2.4. Systematic scenarios

Using a model comparison technique that applies Bayes Factors (2*ln*Bf) or Akaike information criterion through Markov chain Monte Carlo analysis (AICM) to test between alternative scenarios of species delimitation (Aydin et al., 2014; Grummer et al., 2014) allows flexibility for alternative hypotheses and is robust to systems where historical introgression is suspected (Grummer et al., 2014). We performed model comparison tests of alternative systematic hypotheses among designated lineages of North American red squirrels considering all loci within a species-tree framework implemented using *BEAST (Heled and Drummond, 2010). Because *BEAST accommodates different numbers of gene copies for each taxon, we included all samples per lineage that were sequenced for more than a single locus.

We performed Bayes Factor and AICM pairwise tests of alternative hypotheses (Table 2; Fig. S1). All hypotheses considered samples ($n = 60$) representing various combinations of the nine well-supported monophyletic mtDNA (Cytb) lineages: Two widespread lineages (Continental and Northwestern), a Western lineage (combining *T. douglasii* and Baja California samples unless otherwise noted), Vancouver Island, Central Rockies, North Pacific Coast, Sacramento Mountains (NM), Southern Rockies, and Southwestern Sky Islands (Fig. 1). Despite a high likelihood of ongoing gene flow within and among certain lineages, all were included to assess relative nodal support for clade relationships considering multiple loci under three different hypotheses. Hypothesis H1 considered the currently assigned taxonomy (*T. douglasii*, *T. hudsonicus*, and *T. mearnsi*; Fig. 2). Hypothesis H2 considered three species hypothesized by Arbogast et al. (2001): *T. douglasii* (including *T. mearnsi*), *T. fremonti* (Southern Rockies, Sacramento Mountains, and Southwestern Sky Island), and *T. hudsonicus* (Continental, Northwestern, Southeast Alaska, Vancouver Island and Central Rockies). Hypothesis H3 considered all Cytb lineages as independent "species". All hypotheses were compared statistically using both all loci and only nuclear loci.

We produced a separate traits file indicating lineage assignments for all samples under each hypothesis. In BEAUti, for each hypothesis, we unlinked datasets for each locus across all partitions, assigned substitution models by locus, and applied empirical base frequencies. We applied a relaxed clock: uncorrelated lognormal to Cytb as the ucld standard deviation of the rate for this gene when analyzed independently significantly deviated from zero, but assigned a strict clock to nuclear loci to reflect lower divergence over the evolutionary timeframe investigated. We chose a Yule tree prior with piecewise linear and constant root and assigned proper ploidy to each locus. Two independent runs for each hypothesis used MCMC chains of 100 million generations sampling trees every 10,000.

In Tracer, we ran model comparisons to identify the hypothesis that best explained the data considering marginal likelihood

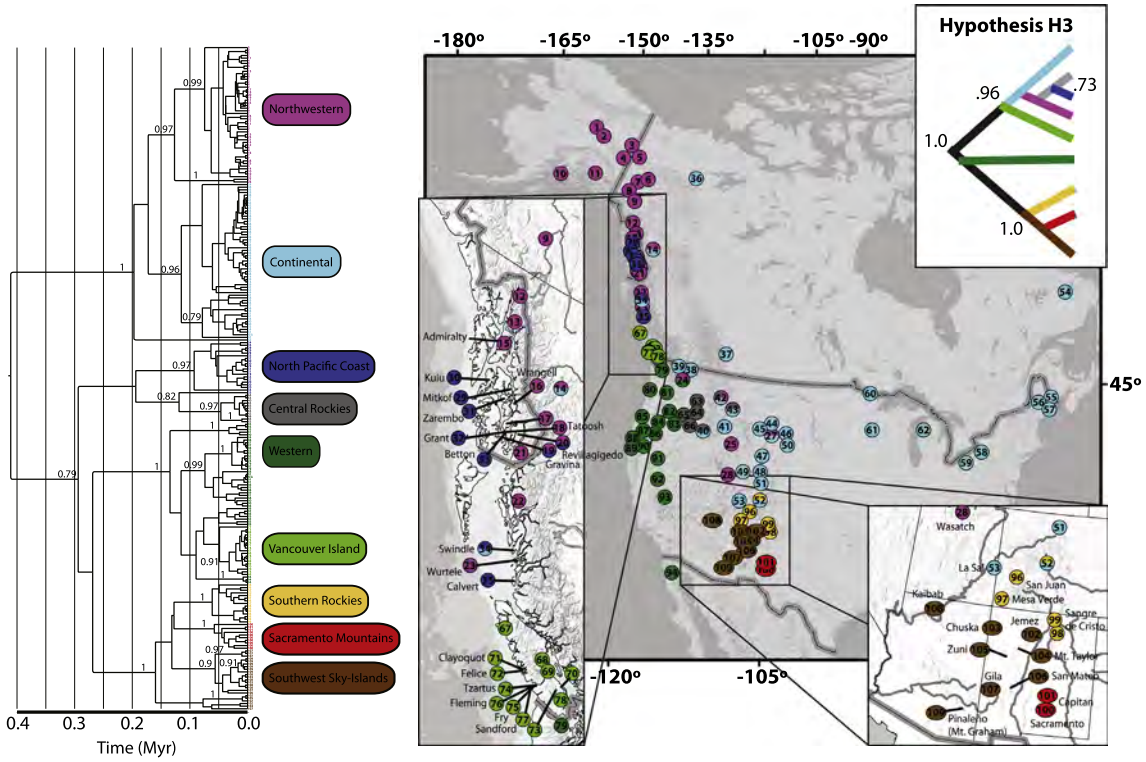

Fig. 3. Left – Chronogram of evolutionary relationships among North American red squirrels (*Tamiasciurus*) based on 771 bp of the mtDNA Cytochrome b gene with a root coalescence estimate from Chavez et al. (2014). Phylogeny estimation was performed in BEAST, providing both posterior probability nodal support values (left of node) and coalescence times (millions of years; italics, right of node). The topology is presented as ultrametric and proportional to an evolutionary timeline (bottom) that extends from the present (right) to the past (left). Tip labels indicate general collecting localities (Appendix A). Major lineages are color coded and coincident with geography. Tip labels indicate sampling localities. Right – Map of the study area indicating general specimen localities for samples of North American red squirrels included in the present study. Locality numbers correspond to those listed in Appendix A. Left inset provides finer detail of localities along the North Pacific Coast. Bottom-right inset provides finer detail of localities within the Southwestern region. Localities are colored according to major mtDNA lineages. Circles with multiple colors indicate general localities where multiple mtDNA lineages are sympatric. For insets, insular populations are labeled by island or mountain range. Top inset provides the results of a *BEAST species tree analysis (including empirical topology and nodal support values) considering systematic hypothesis H3 with nine independent taxa color-coded according to mtDNA lineages. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Genetic polymorphism and demographic statistics considering 771 bp of the mtDNA Cytochrome b gene among major North American red squirrel lineages. Abbreviations include *n* = sample size; *S* = number of segregating sites; *h* = number of haplotypes; *Hd* = haplotype diversity; π = nucleotide diversity; *D* = Tajima's *D* (with associated *P*-value); *R2* = Ramos-Onsins and Rozas *R2* (with associated *P*-value); μ = lineage-specific substitution rate (percent per million years) considering rates weighted by branch lengths for each lineage from the Cytochrome b BEAST chronogram. The rate given for all lineages combined was calculated in BEAST using a root calibration of 0.4229 Myr (HPD: 0.2979–0.5538; Chavez et al., 2014). N/A = not applicable. Bold values are statistically significant at $P < 0.05$.

	n	*S*	*h*	*Hd*	π	*D*	*P*(*D*)	*R2*	*P*(*R2*)	μ
All	252	134	142	0.982	0.0181	N/A	N/A	N/A	N/A	5.23
Central Rockies	11	4	4	0.600	0.0015	−0.542	0.324	0.142	0.107	5.14
Continental	60	41	34	0.866	0.0045	**−2.167**	**0.001**	**0.046**	**0.000**	5.20
Northwestern	52	45	32	0.924	0.0031	**−2.593**	**0.000**	**0.022**	**0.000**	5.35
North Pacific Coast	20	15	16	0.963	0.0040	−1.192	0.132	0.088	0.056	5.03
Sacramento Mountains	10	11	7	0.933	0.0035	−1.407	0.096	0.124	0.056	5.26
Southern Rockies	15	14	10	0.924	0.0035	−1.509	0.064	**0.079**	**0.000**	5.42
Southwestern Sky Islands	22	17	12	0.905	0.0037	−1.413	0.062	**0.073**	**0.011**	5.26
Vancouver Island	19	8	7	0.544	0.0012	**−2.022**	**0.001**	**0.084**	**0.002**	5.21
Western	42	35	26	0.962	0.0067	−1.325	0.074	0.065	0.059	5.25

estimates of competing hypotheses using both 2*ln*Bf and 2AICM scores. Scores were ranked for each hypothesis only with respect to the "best" hypothesis (that with the marginal likelihood estimate closest to zero). As described in Grummer et al. (2014), and based on the recommendations of Kass and Raftery (1995), the strength of support of 2*ln*Bf for the best hypothesis (labeled as N/A) compared with competing hypotheses was as follows: 0–2 means no significant support; 2–6 means positive support for the best hypothesis (N/A) over this competing scenario; 6–10 means strong support for the best hypothesis; and >10 means decisive rejection of the competing hypothesis compared with the best hypothesis. As in Grummer et al. (2014), we recognized distinct lineages from hypotheses (topologies) where 2*ln*Bf support for the leading topology was >10 in pairwise comparisons with competing hypotheses. Similarly for AICM which equates using two times the sample mean log likelihood, we use a cutoff of >20 for 2AICM (multiplied by 2 for consistency with Bayes Factor methods).

Table 2
AICM and Bayes Factor (2*ln*Bf) results considering marginal likelihood estimates from alternative species-tree hypotheses of relationships among major lineages of North American red squirrels (see Fig. S1 for scenario topologies). The hypothesis receiving the best marginal-likelihood score is indicated by N/A. 2AICM and 2*ln*Bf scores for other scenarios reflect comparative strength of the best supported hypothesis, where for 2*ln*Bf a score of 0–2 means "not worth more than a bare mention", 2–6 means "positive" support for the best hypothesis over that alternative, 6–10 provides "strong" support, and >10 means "decisive" support in distinguishing between best and competing hypotheses (after Kass and Raftery, 1995). For 2AICM scores, we consider >20 as decisive, 12–20 as strong, and 4–12 as positive support for the best hypothesis over that alternative. Hypotheses were analyzed considering all five loci (both mtDNA and nuDNA) and using only the four nuclear loci.

Scenario	Description	All five loci		Four nuDNA loci	
		2AICM	2*ln*Bf	2AICM	2*ln*Bf
H1	3 species as currently described (*T. douglasii*, *T. hudsonicus*, *T. mearnsi*)	N/A	10.28	5.72	10.74
H2	3 species as per Arbogast et al. (2001; *T. douglasii*, *T. hudsonicus*, *T. fremonti*)	27.85	N/A	N/A	N/A
H3	All lineages considered separately	104.10	22.76	31.70	16.06

2.5. Bioclimatic envelope modeling

We used bioclimatic envelope modeling (BEM, Araújo and Peterson, 2012) to characterize occupied distributions and reconstruct paleodistributions of each species. We used these niche-based tests as an independent perspective of ecological divergence among putative species using a three-step approach: (1) reconstruct contemporary distributions and project (transfer) the final model to ancestral climate conditions (i.e., mid-Holocene and LGM); (2) assess spatial overlap of predicted distributions for all periods; and (3) conduct niche identity tests using geographic-based approaches (Warren et al., 2008, 2010).

2.5.1. Occurrence and environmental data

BEMs are often constructed from two forms of data: occurrence records and environmental layers. We downloaded all available records of North American red squirrels from VertNet (accessed February 2015) and conducted a series of screening and filtering steps to reduce bias. We removed all samples with a georeferenced error >5 km, those that failed to provide an estimate of error, and those that were outside the known distribution of *Tamiasciurus*. We also removed samples prior to 1940. To reduce spatial autocorrelation, we used a custom aggregated reduction technique (Fourcade et al., 2014; Warren et al., 2014) by retaining a single random sample within 10 km^2 radius and discarding other spatially redundant locations.

To assess lineage-based distributional overlap and test for recent niche divergence among evolutionarily independent groups we used mtDNA haplotypes to quantify areas occupied by lineages. First, we added a minimum convex polygon in ArcGIS v10.2 to each lineage-based set of points and applied a 200 km buffer to assign all points within each polygon to respective mtDNA lineages. We then reassigned mtDNA samples to putative species identified from the best model in tests of evolutionary hypotheses.

The geographic extent of species is an important consideration when using correlative models (Barve et al., 2011). However, the total extent of *Tamiasciurus* is likely too broad considering our goals of pairwise tests between geographically limited species. Based on the geographic distribution of putative species, we divided the study area using the three regional clades (systematic hypothesis H2; Table 1; Fig. S1) and delimited their extents to 100 km beyond the N/S and E/W extremes of each distribution.

Next, we generated bias files for each species to optimize background and occurrence point selection within study extents. Bias files are frequently used in correlative modeling to avoid oversampling and can offset effects of geographic biases often associated with coordinate-based data, decreasing commission (false-positive) error rates (Anderson and Raza, 2010; Barve et al., 2011; Merow et al., 2013). We used SDMToolBox v1.1c (Brown, 2014) to generate the bias files for each species, using the "Sample by Buffered Local Adaptive Convex-Hull" tool that limits background points (Thuiller et al., 2009; Barbet-Massin et al., 2012) and set the buffer distance to 75 km and alpha parameter to four.

We used 19 bioclimatic (temperature and precipitation) variables from the WorldClim database to quantify ecological tolerances of each lineage. These landscape-level data are often useful for assessing both current and paleodistributions (Malaney and Cook, 2013; Waltari and Guralnick, 2009; Waltari et al., 2007), and also for assessing Grinnellian-based niche divergence (McCormack et al., 2010). Then, we identified tightly correlated ($\geqslant$0.80) and removed redundant variables, favoring those more temporally inclusive (e.g., bio11 – mean temperature of the coldest quarter versus bio6 – minimum temperature of the coldest month) or relevant to squirrel ecology (e.g., cone mast is often linked to seasonal conditions; bio15 – precipitation seasonality).

2.5.2. Correlative modeling

We used MaxEnt version 3.3.3e (Phillips and Dudik, 2008) due to superior performance over other correlative modeling approaches (Elith et al., 2006; Peterson et al., 2007) and ability to provide statistical comparisons among models (Elith et al., 2011; Merow et al., 2013). MaxEnt uses presence data in comparison with random background samples to estimate species distributions (Elith et al., 2011; Guillera-Arroita et al., 2015; Merow et al., 2013), but is optimized with multiple default settings that require testing prior to modeling to enhance model performance (Anderson and Gonzalez, 2011). Consequently, we conducted criterion-based model selection (Burnham and Anderson, 2002; Warren and Seifert, 2011) by assessing different combinations of the feature class types (FC) and regularization multipliers (RM) using ENMTools v.1.4.4 (Warren et al., 2010). We constructed single models for each species by applying alternate FCs (e.g., L – linear; LQ – linear and quadratic; H – hinge; LQH – linear, quadratic, and hinge; LQHPT – LQH, product, and threshold) and alternate RMs ranging from 0.01 to 5.0 at 0.5 intervals. In sum, we tested 55 alternate models for each species (5 FCs $\times$ 11 RMs), identifying optimum model settings using corrected Akaike information criterion (AICc).

We then conducted final modeling for each species using 20 replicates, log-scale outputs, and set number of iterations to 5 k, keeping the default convergence threshold (=0.00001). During replicate models, we applied the bias file for background sampling, retained 20% of presence localities as a training dataset, and used subsampling run type (jackknife approach) because of small sample sizes for some mtDNA lineages (Pearson et al., 2007; Shcheglovitova and Anderson, 2013). Standard deviations across all replicates were minor.

MaxEnt produces a set of continuous surfaces and we used the mean of replicated models to represent relative suitability/likelihood (Guillera-Arroita et al., 2015; Richmond et al., 2010). To assess differences between high suitability for each species, we constructed a single raster by calculating the difference between the continuous mean logistic outputs of comparative lineages (DiffAB = species A – species B). Further, we created a binary distribution of suitable and unsuitable areas using the equal training sensitivity and specificity logistic threshold for the spatial projection of final models (Pearson et al., 2007) and used the

threshold-applied distributions to characterize paleodistributions and assess distributional shifts (see below).

2.5.3. Paleodistributions

We reconstructed paleodistributions of individual lineages to understand the history of geographic distributions, frequently yielding insights of ancestral areas as well as regions of historic admixture (Pelletier et al., 2015). Specifically, we projected predictions for the mid-Holocene (contemporary models; i.e., Younger Dryas) and late-Pleistocene (i.e., Last Glacial Maximum – LGM). Considering many North American mammals have shifted distributions (Malaney and Cook, 2013; Lessa et al., 2003), we expanded the spatial extents through past timeframes by 500 km to include areas nearby that might have been historically occupied by ancestral populations. Further, we validated paleodistribution reconstructions with fossil records obtained from FaunMap database (accessed March, 2015). We then assessed spatial overlap among clades using techniques analogous to contemporary overlap measurements.

2.5.4. Model-based niche divergence

To assess the degree of niche overlap among the major clades, we used the G-space niche-identity test using the *D* statistic (Schoener, 1968; Warren et al., 2008), which ranges from 0 (discordant) to 1.0 (identical). The niche-identity test is used to assess whether measured overlap is significantly different (one-tailed test) from an underlying null expectation. This approach randomized samples from each lineage pair using 100 pseudoreplicates for each pairwise test.

3. Results

3.1. Gene trees and evolutionary rates

A previously calculated age for the T_{MRCA} of all North American red squirrels of 0.4229 Myr (Chavez et al., 2014) provided an average mutation rate of 5.23% per million years (10.46% divergence rate) for the Cytb dataset (Table 1). Substitution rates ranging from 5.03% to 5.46% per million years were recovered for nominal lineages within the red squirrel Cytb genealogy (Table 1). The chronogram indicates nine well-supported, spatially-structured lineages (Fig. 3). Two lineages exhibit broad distributions, often within previously glaciated areas, indicative of post-glacial population expansion. The Continental lineage is broadly distributed across North America whereas the Northwestern lineage is coincident with the Rocky Mountain cordillera. These two lineages together form a well-supported clade distinct from all other North American red squirrels. Other well-supported lineages include the Central Rockies with a limited distribution within the inland forests of Idaho, western Montana, and eastern Oregon. The North Pacific Coast (NPC) lineage is only distributed on islands of the Alexander Archipelago (Betton, Grant, Gravina, Kuiu, Mitkof, Revillagigedo, and Zarembo islands), and in British Columbia on Calvert and Swindle islands (Fig. 3). Mitochondrial signatures indicative of both NPC and Northwestern lineages occur on Gravina and Revillagigedo islands of the southern Alexander Archipelago. The Northwestern lineage also occurs on Admiralty (introduced), Tatoosh, and Wrangell islands. The Western mtDNA lineage is paraphyletic with respect to Vancouver Island (due to recognized mito-nuclear discord) and is distributed from Baja California (*T. mearnsi*) north to southern British Columbia. Finally, substructure within the well-supported Southwestern clade includes lineages associated with the Sacramento Mountains of New Mexico, the Southern Rockies of Colorado and northern New Mexico, and two paraphyletic lineages associated with the Southwestern Sky Island archipelago (Fig. 3).

The initial dichotomy within the Cytb chronogram is dated to ~400 ka. Continental and Northwestern lineages were estimated to have split at 200 ka. Coalescence of all Southwestern lineages is coincident with the Illinoian glacial period (~160 ka) although initial divergence from other squirrel lineages is dated >250 ka. Coalescence of most terminal lineages is <100 ka.

Independent nuclear genealogies were less well resolved although Western haplotypes were consistently private across all loci (Fig. S2). All well-supported mtDNA lineages exhibited at least one private nuclear haplotype. Continental and Northwestern haplotypes were closely related, as were those of all Southwestern lineages. Within the Southwestern Sky Island lineages, the federally endangered Mt. Graham (Pinaleño Mountains) population exhibited private haplotypes over all loci except one (Fig. 3; Fig. S2).

3.2. Diversity and demographics

Mitochondrial DNA haplotype and nucleotide diversity were lowest for the Vancouver Island lineage and highest for the Western lineage (Table 1). Within the Continental lineage, samples collected from western and eastern North America were divergent (Fig. 3). Only Continental and Northwestern lineages exhibited consistent signals of demographic expansion over multiple tests, a finding also supported by star network topologies (Table 1; Fig. S2). BSPs for these lineages indicated the most dramatic population growth coincident with post-glacial expansion (Fig. S3). BSPs for both the NPC and Western lineages also indicated significant population growth but non-significant demographic expansion, suggesting *in situ* growth through the late-glacial and Holocene timeframes. Skyline changes for Central Rockies, Sacramento Mountains, Southern Rockies and combined Southwestern Sky Islands lineages failed to reach the 95% highest probability distributions indicating minimal population growth (Fig. S3). Uncorrected pairwise mtDNA genetic distances between the 9 major lineages ranged from 0.84% to 3.48% sequence divergence with highest divergence between Northwestern and Southern Rockies lineages.

3.3. Systematic hypotheses

All species-tree topologies strongly supported the presence of multiple species and lack of reciprocal monophyly of *T. hudsonicus* as currently recognized. Each systematic hypothesis is reported in conjunction with the geographic ranges of nominal taxa according to respective hypotheses shown on maps, and these phylogenies reflect the results of species-tree analyses, including relative branch lengths, empirical topologies, and posterior probabilities at nodes (Figs. 1–3, S1). When Southwestern lineages were considered as a separate species, they were consistently less divergent from *T. douglasii* than from the remaining lineages of *T. hudsonicus*, although low posterior probabilities coupled with basal coalescences support the possibility of a radiation of three species through initial fragmentation, dating to the pre-Illinoian (~400 ka). Based on all loci, Bayes Factor model comparisons decisively supported Hypothesis H2 as the best systematic arrangement (Fig. S1; Table 2). AICM comparisons using only nuclear loci also supported H2 above other scenarios. Hypothesis H2 provides highest likelihood for true species relationships, considering all species tree estimates, and reflects three species. As also reflected by divergent ecological associations, we recognize the Douglas squirrel, *T. douglasii* consisting of the Western lineage, the southwestern red squirrel, *T. fremonti* Audubon and Bachman, 1853, consisting of the Southern Rockies, Sacramento Mountains,

and Southwestern Sky Islands lineages, and the American red squirrel, *T. hudsonicus* consisting of the remaining 5 lineages.

3.4. Bioclimatic envelope modeling

3.4.1. Niche variables and occurrence points

We obtained 20 niche variables that exhibited varying levels of importance and correlation across the study region (Table S1). For occurrence points, we obtained a total of 1160 *T. douglasii* (including *T. mearnsi*), and 3413 *T. hudsonicus* records. After processing (screening, partitioning, thinning, and clipping), we identified 279 *T. douglasii* and 740 *T. hudsonicus* records for reconstructing distributions and conducting niche tests. We then assigned 59 of the *T. hudsonicus* records from the Southwest as *T. fremonti* using genetic data as a guide.

3.4.2. Model performance

We found that optimized settings reflected a best-fit for our study system using model selection that increased the regularization penalty, simplified features, and reduced the overall dimensionality of final models. MaxEnt performed well with mean training AUC >0.85 for all analyses, often a positive indication of optimized models. Randomly withheld test data were predicted significantly better than random with AUC >0.90 for all analyses (Table 3) and AUC standard deviations all <0.05. Threshold-dependent approaches yielded results with low omissions and significantly better omission rates from threshold-dependent predictions than from random predictions.

3.4.3. Current distributions and overlap

Distributions of North American red squirrels were best predicted ($\geqslant$10% variable importance) by three variables for each species and six variables total (Table 3). For *T. douglasii*, >73% of the variation was accounted for by winter precipitation (bio19 = 39.7%), precipitation seasonality (bio15 = 20.0%), and isothermality (bio3 = 13.5%). For *T. hudsonicus*, over 50% variable importance was due to isothermality (31.3%) and winter precipitation (21.5%), with mean annual temperature (bio1 = 12.7%) the third most important, totaling 79.3%. The three most important variables (65.5%) for *T. fremonti* included average summer temperature (bio5 = 50.0%), temperature seasonality (bio4 = 13.5%), and like other species, winter precipitation (15.8%).

Current distributions predicted for each species overlap (Fig. 2), with *T. hudsonicus* sharing predicted range with *T. douglasii* in the Pacific Northwest (overlap = 77,754 km^2) and with *T. fremonti* in the Southern Rocky Mountains (overlap = 71,408 km^2).

3.4.4. Paleodistributions

We document distributional change for all species between the LGM, mid-Holocene, and present. Even after applying thresholds of currently occupied distributions and projecting to historical conditions (i.e., mid-Holocene and LGM), most fossil records (>80%, Figs. S4–S6) were accurately predicted. Predicted ancestral areas (LGM) for *T. douglasii* were centered on northern California (Fig. S4) with isolated regions in southern California and northern Baja, and although generally further south, total predicted area was only slightly larger than mid-Holocene and today. Predicted distributions shifted to higher elevations and more northern latitudes during the Holocene and are most restricted in total range at present. For *T. fremonti*, LGM distributions were projected to be >2$\times$ the extent of present distributions, with a retraction to higher elevations during the Holocene rather than a shift across latitude (Fig. S5). For *T. hudsonicus*, latitudinal shifts appear to have been the dominant change from LGM to mid-Holocene and today (Fig. S6). Potential LGM occupation included ancestral regions along the North Pacific Coast and within eastern Beringia (Alaska).

3.4.5. Stable regions for squirrels

By overlaying predictions from all models, we identified stable regions for all three species, although eco-geographic stability varied. For *T. douglasii,* three regions have remained relatively stable between the LGM and today, including medium elevations in the Sierra Nevada of eastern California, the Coast Ranges in northwestern California and Oregon, and high elevations of southern California and Baja Mexico. The total combined stable area for *T. douglasii* is ca. 69,000 km^2 (20.8% of the present distribution). For *T. fremonti*, we detected three temporally stable areas largely coincident in extent with the current range, including the Rocky Mountains of Colorado and New Mexico, the Sacramento Mountains in southeastern New Mexico, and the Mogollon Mountains of New Mexico and Arizona. When combined, these stable areas for *T. fremonti* totaled ca. 111,000 km^2 (62.9% of the present distribution). In contrast to *T. douglasii* and *T fremonti, T. hudsonicus* had few consistently occupied regions between the LGM and today totaling <80,000 km^2, a very small proportion of the total potential range in any timeframe (2% of present distribution). Whereas historic areas are largely coincident with temporally stable regions for *T. fremonti*, and slightly less so for *T. douglasii*, past predictions for *T. hudsonicus* are largely independent of interglacial (recent) distributions.

3.4.6. Niche identity

Despite large areas of potential distributional overlap between species (Fig. 2), the background test of niche identity indicated that each squirrel species occupies distinct ecospace when compared to expected niche overlap from pooled samples. All three species have non-identical niches and distributions (Schoener's *D* values $\leqslant$0.50).

Table 3
Relative importance of niche model variables. During modeling, we conducted 20 replicates, retained 20% of samples for training, and applied optimized parameters from model selection. The training, test, and standard deviation of AUC (=Area Under Curve) scores are measures of model performance. Below the AUC metrics are the relative contributions of variables. Variables shown contributed >10% to each model and were used for ecological interpretation, corresponding to the top three variables in each model. Symbols reflect results of the jackknife test of variable importance showing the highest gain when used in isolation ($*$), the variable that decreased the gain most when omitted (#), and the variable with the highest permutation importance ($).

AUC/variable	*T. douglasii*	*T. fremonti*	*T. hudsonicus*
Test AUC	0.942	0.911	0.905
AUC SD	0.008	0.047	0.012
Annual Temperature (Bio1)			12.7*
Isothermality (Bio3)	13.5		31.3$^{\#,\$}$
Temperature Seasonality (Bio4)		13.5	
Summer Temperature (Bio5)		50.0$^{*,\$}$	
Precipitation Seasonality (Bio15)	20.0$^{\#,\$}$		
Winter Precipitation (Bio19)	39.7*	15.8$^{\#}$	21.5

4. Discussion

This comprehensive phylogenetic assessment of the North American red squirrels provides a more complex interpretation of speciation within these forest obligate species and characterizes processes that also influence other species of this increasingly fragmented community. Congruence across species hints at fundamental ecogeographic variability on a continental scale that has predictable evolutionary consequences. Three main dynamics emerge from our analyses.

The first dynamic reflects evolutionary complexity across North America among forest dwelling species, with a dichotomy that contrasts minimal evolutionary structure in eastern North America (a single widespread lineage for red squirrels) with comparatively complex structure in the west (three species and multiple lineages). This east/west split reflects the Mississippi discontinuity as now reported across multiple other taxa (e.g., Soltis et al., 2006), with the Great Plains Ecoregion serving as a major barrier between east and west, and a gradient of increasing genetic complexity found within temperate forested biomes from east to west. Within the west, three geographic centers of diversity exist as reflected by *T. douglasii* in westernmost generally mesic forests, *T. fremonti* distributed through the Southwest, and *T. hudsonicus* with an extensive distribution through remaining interconnected forests.

The second dynamic reflects regional variability in spatial responses of species to long-term climate trends. Both genetic demographic analyses and niche predictions indicate relative stability through the southwest region with over 60% of current niche for *T. fremonti* consistently predicted as suitable through all recent (Late Quaternary) climate phases. By contrast, all lineages within *T. hudsonicus* except for the Central Rockies exhibit significant signals of recent demographic expansion and virtually no persistent niche space through timeframes. Dramatically different histories for *T. hudsonicus* and *T. fremonti* reflect alternate modes of diversification. In the southwest, *T. fremonti* is the product of ancient peripatric isolation and subsequent divergence accompanied by periodic fragmentation/reconnection at local scales. In contrast, glacial and interglacial phase distributions of *T. hudsonicus* are non-overlapping, and such vast spatial displacement likely reflects repeated population extirpations as leading edge expansions and contractions predominate through time, resulting in species-wide range shifts. Across the continent-wide distribution of *T. hudsonicus,* broad-scale fragmentation and range contractions with subsequent differentiation in multiple isolated areas, generated high overall genetic diversity. *Tamiasciurus douglasii* exhibits an intermediate history with reduced glacial–interglacial phase displacement and medium-term persistence of populations.

The third major dynamic is relatively rapid radiation of three species despite repeated and ongoing gene flow, reflecting again high regional complexity in western North America and climate phase expansion–contraction dynamics. Similar episodes of rapid diversification are being uncovered in other forest-dwelling mammals with shared geographic distributions (e.g., Shafer et al., 2010). For instance, both the *Sorex cinereus* complex and *Sorex palustris* complex exhibit longitudinally distributed lineages that reflect a Mississippi discontinuity, rapid speciation, high genetic complexity in the west, and ongoing gene flow among species (Hope et al., 2012, 2014a). Similarities in diversification processes are also found among other sciurids. Chipmunks (multiple genera; Patterson and Norris, 2015) have a deeper history of speciation than red squirrels and provide a model for examining how gene flow has impacted the formation of species (Good et al., 2008; Sullivan et al., 2014). In addition, both intra- and inter-specific distributional histories among chipmunks reflect low diversity in eastern North America (*Tamias striatus* and a single lineage of *Neotamias minimus*), as opposed to 22 species that have arisen in western regions (Hall, 1981) with extensive hybridization at range boundaries. Marmots (Genus *Marmota*) also exhibit inter-specific gene flow (Kerhoulas et al., 2015) and the history of diversification of multiple genera of ground squirrels has been accompanied by periodic episodes of introgressive hybridization (Helgen et al., 2009). Recent speciation, coupled with replicated episodes of gene flow, both spatially and temporally, among North American red squirrels should provide novel perspectives on the formation of Nearctic species (Abbott et al., 2013).

4.1. Systematic relationships

Given the extensive range of red squirrels, a comprehensive assessment of systematic relationships and evolutionary history within *Tamiasciurus* has been hampered by limited geographic sampling and associated multi-locus genetic perspectives. Hall (1981) identified substantial morphological variation, recognizing 4 subspecies within *T. douglasii* and 25 subspecies within *T. hudsonicus*. Subsequently, Lindsay (1981) raised *T. d. mearnsi* to species status based on distinctive morphospace among the three species, but lacking range-wide sampling. The first geographically widespread genetic assessment based on a single locus (Arbogast et al., 2001) found no genetic divergence between *T. douglasii* and *T. mearnsi* and instead recovered three independent lineages as western (combined *T. douglasii* and *T. mearnsi*), eastern (all *T. hudsonicus* except for Southwestern populations) and Southwestern (Arizona, New Mexico, and southern Colorado populations of *T. hudsonicus*). Additional mtDNA sequence data identified a paraphyletic relationship of *T. hudsonicus* with respect to *T. douglasii* (including *T. mearnsi*) and reported a distinct lineage located in the Alexander Archipelago of Southeast Alaska (Barber, 2007). Most recently, multiple nuclear loci suggest refugial isolation on Vancouver Island (Chavez et al., 2014), and indicate a complex history of diversification including gene flow, as has been found elsewhere between *T. hudsonicus* and *T. douglasii* (Chavez et al., 2011).

Considering differentiation across multiple loci, climatic niche divergence, and previous morphological evidence, the taxonomy of red squirrels should be updated. The isolated population occurring in Baja California (previously *T. mearnsii*) is minimally divergent from the remainder of the Western lineage over all loci examined; however, a combined western clade representing the Douglas squirrel (*T. douglasii* and *T. mearnsii*) forms one of three species that are well supported over all analyses. The other two species are the southwestern red squirrel (*T. fremonti*; including Southern Rockies, Sacramento Mountains, and Southwestern Sky Island lineages), and the broadly distributed American red squirrel (*T. hudsonicus*) that includes five mtDNA lineages (Continental, Northwestern, Central Rockies, North Pacific Coast, and Vancouver Island). These three species better reflect the evolutionary history and ecology of boreal forest obligates and should improve management and conservation planning.

Although our methods allow for more rigorous representation of systematic relationships within *Tamiasciurus*, the revised taxonomy does not fully account for either incomplete lineage sorting or recent and historic admixture. In this regard, a closer appraisal of the nuclear evidence compared with matrilineal inheritance is informative (Fahey et al., 2014; Hung et al., 2012). Three mtDNA lineages are highly supported as unique among red squirrels, including Vancouver Island, Central Rockies, and NPC lineages; however, all exhibit strong evidence of introgression across different temporal scales. Vancouver Island has fixed mito-nuclear discord where the mitochondria are indicative of *T. douglasii*, but only three haplotypes among nuclear loci examined are private

(most being shared with *T. hudsonicus*). Given the single mtDNA lineage present on Vancouver Island, we concur with Chavez et al. (2014) that this population represents a refugial lineage that persisted through at least part of the last glacial, resulting from a small founder event by hybrid individuals of *T. douglasii*/*T. hudsonicus*. North Pacific Coast and Central Rockies mtDNA lineages are more difficult to interpret. Both exhibit geographically restricted and private nuclear haplotypes, but also share haplotypes with other populations, particularly within *T. hudsonicus* and the Vancouver Island lineage.

4.2. Niche variability among species

Consistent with updated systematic relationships, modeled distributions are indicative of ecological differences among all three species. However, we detected two areas of geographic overlap coincident with regions of hybridization. Overlaps are likely the product of incomplete ecological divergence that includes a narrow set of environmental conditions. For example, although all three species have overall discordant niches ($D = 0.35–0.49$), they all appear to respond similarly to winter precipitation (either the most important or second most important variable), where each is predicted in areas with between 200 and 1000 mm of winter precipitation. Therefore, incomplete ecological differences are likely because of a combination of winter precipitation, temperature evenness, and seasonal variation in temperature and/or precipitation, at distributional peripheries. As a result, in the Rocky Mountains, temperature seasonality differs less between *T. hudsonicus* and *T. fremonti*, allowing these genetically and ecologically divergent species to overlap in peripheral areas. Similarly, in the Pacific Northwest, isothermality (temperature evenness) is most consistent where *T. douglasii* and *T. hudsonicus* meet, allowing them to occupy peripheral areas. There are likely also temporal differences in spatial overlap. For example, the current overlap in the Rocky Mountains may have formed only recently, whereas repeated episodes of isolation and reconnection in Northwestern North America likely permitted greater gene flow in this area.

4.3. Ecology and conservation of regional forest ecosystems

Isolated forest-associated species often reflect classic dynamics of land-bridge island biogeography (Brown, 1971; Patterson, 1982). Because of their age, size, and isolation (e.g., Frey et al., 2007) genetic diversity and effective population size (both at present and historically) likely dictate risk of extirpation due to warming and drying climatic trends compounded with stochastic events (e.g., fire – Koprowski et al., 2005). Conservation of forest peripheral isolates is critical considering that many populations among forest-dwelling species: (1) occur in small, contracting patches of habitat (Holocene refugia), (2) contribute disproportionately to overall genetic diversity, and (3) often exhibit unique adaptations due to their occurrence at the edge of a species' range (Channell and Lomolino, 2000; Hampe and Petit, 2005; Koprowski, 2005).

A clearer understanding of the historical biogeography and systematics of these squirrels enables us to better assess conservation implications for peripheral isolates, due to comprehensive geographic sampling and integrated eco-evolutionary methods (Hope et al., 2013). Peripheral isolates experience high risk of extirpation for several reasons. Small population sizes lead to reduced genetic diversity, although differential selection may contribute to increased rates of divergence and potentially local adaptation (Losos and Ricklefs, 2009). Isolates are also at increased risk of stochastic events coupled with marginal ecological conditions, as has been exemplified by the Mt. Graham red squirrels in southern Arizona (Koprowski et al., 2005) and human-mediated habitat fragmentation. Finally, if isolation persists for extended periods, then subsequent admixture or genetic "rescue" from other populations may dilute recently evolved adaptations, and erode or swamp unique diversity through introgression (Tallmon et al., 2004).

Several populations within North American red squirrel species are under increased threat of extinction due to peripheral isolation. Within *T. douglasii*, the Baja California populations (*T. d. mearnsi*) typify a peripheral isolate, occurring in marginal pine/fir forest habitat through a narrow altitudinal range, with low population density, diagnosable morphological features, and unique haplotypes (De Grammont and Cuarón, 2008). In addition, these populations exhibit unique behavioral and ecological adaptation that are not seen further north (e.g., Koprowski et al., 2006). Furthermore, due to the effects of warming and drying climate trends, continued habitat fragmentation (e.g., wildfire, logging, grazing), and competition from introduced eastern gray squirrels, this southernmost refugial population should be closely monitored (De Grammont and Cuarón, 2008).

Within *T. hudsonicus*, multiple peripheral isolates exist. The hybrid population distributed on Vancouver Island and multiple satellite islands (Fig. 3) is distinct from others along the NPC, indicating the role of multiple isolated refugia in the Pacific Northwest during the last glacial phase. The NPC lineage has an extensive distribution through Southeast Alaska and coastal British Columbia, with six island populations appearing to represent a pure NPC mitochondrial lineage, and three islands where multiple mitochondrial lineages occur. More comprehensive sampling of the vast Pacific coastal archipelagos is needed to clarify the spatial extent of coastal lineages (Fig. 3). Nuclear loci provide a more complex interpretation that may reflect recent or past hybridization or incomplete lineage sorting. The NPC harbors endemic diversity over multiple plant and animal taxa reflecting a long and repeated history of colonization interspersed with isolation on islands due to raised sea levels during interglacials, and isolation in refugia due to ice sheet barriers during glacial phases (Cook et al., 2001). For example, mammals such as ermine (Dawson et al., 2014), wolves (Weckworth et al., 2010, 2015) and marten (Small et al., 2003) show similar patterns of differentiation in this coastal region, likely reflecting prolonged isolation from continental populations. Considering multiple human-mediated introductions of squirrels to individual islands in Southeast Alaska (MacDonald and Cook, 1996), and other human impacts such as old growth timber harvest, squirrels endemic to particular islands may be at high risk. A clearer understanding of the geographic extent of the NPC lineage is imperative, including the dynamics and history of population admixture between discrete lineages. Multiple island populations through this region should provide a lucrative system for investigating hybrid dynamics and processes of local adaptation using genomic methods.

Tamiasciurus fremonti is also represented by multiple insular populations. Of high conservation concern, the Mt. Graham population of *T. fremonti* in the Pinaleño Mountains of Arizona is here assessed for the first time as part of a range-wide genetic evaluation of the species in context with its sister species. We confirm that this population is genetically distinct across loci, but most similar to populations from the Kaibab Plateau in northern Arizona and the Gila region of western New Mexico. In addition to the Pinaleño Mountains, squirrels of the San Mateo Range in central New Mexico appear to be genetically divergent, but our sampling is limited to a single individual. Perhaps most surprisingly, squirrels from the Sacramento Mountains in south-central New Mexico constitute a highly divergent lineage within *T. fremonti*, dated to roughly the last interglacial period (130 ka) and coincident with initial diversification among all lineages within the Southwest. Little evidence of demographic expansion among any lineages of *T. fremonti*, and distinct diversity coincident with isolated mountain ranges indicates a potentially extinction driven system in the

future, if lack of connectivity is coupled with further degradation of montane forested habitats. Limited current gene flow between populations indicates that this species is of high conservation concern. Within the Sacramento Mountains, isolation may be exacerbated by their "high and dry" nature. Red squirrels in the Southwest are restricted to higher elevation conifer forests although they readily utilize blue spruce (*Picea pungens*) corridors along riparian systems. During the last glacial phase, spruce likely extended more widely along riparian corridors, facilitating connections between higher elevation forested areas through the Southwestern Sky Island Archipelago. However, no major riparian corridors now exist between the Sacramento Mountains and other sky islands. Niche predictions support relative isolation of this region through multiple timeframes (Fig. S5).

A significant contribution of a multi-locus and integrated niche-prediction approach to conservation phylogenetics is that, in addition to considering unique peripheral diversity, we can evaluate evolutionary potential within more complex regions where multiple zones of contact exist between sibling species through time (Sullivan et al., 2014). Our niche models predict two broad regions of overlap between the three species of red squirrels, centered over the Southern Rockies and the Pacific Northwest/Interior Highlands ecosystems. Nuclear loci suggest ongoing gene flow. However, considering multiple divergent matrilineages, these regions of contact are likely representative of recent (Holocene) admixture, with hybridization an ongoing dynamic process as climate and environments continue to shift (Hamilton and Miller, 2016; Taylor et al., 2015). Considering that hybridization may either be detrimental to parental species or promote both adaptive potential and diversification (Brennan et al., 2015), these regions of complex contemporary interactions between species, in addition to peripheral populations, constitute critical areas for future research, and conservation-based management.

4.4. Refugia and important ancestral areas of occupation

This multi-locus assessment provides valuable insight for the temporal and spatial development of continent-wide ecological and genetic diversity. Because genetic coalescent estimates and demographics coupled with lineage-specific BEMs can highlight regional responses (Hope et al., 2015), red squirrels provide a basis for identifying common processes shaping the biogeography of forest communities. From niche predictions through time for *T. hudsonicus* (Fig. S7) and multiple distinct matrilineages, we infer several ancestral areas of allopatry during the last glacial phase, generally coincident with those discussed broadly for other taxa (e.g., Swenson and Howard, 2005). Unique nuclear diversity within mitogroups, although minimal, is consistent with these predictions. Major areas were centered upon the eastern and western U.S. south of continental ice sheets and within Beringia, the former two being corroborated by fossil evidence (Kurtén and Anderson, 1980). The Beringian refugium (specifically considering the Northwestern matrilineage of *T. hudsonicus*) was previously hypothesized (Chavez et al., 2014). Our expanded genetic sampling indicates very low historic population size and recent rapid demographic expansion within this lineage (Fig. S3), but with high relative genetic diversity at highest latitudes. Coupled with the current pervasive distribution through Southeast Alaska (not considering human reintroductions), the evidence suggests an early bout of colonization through this region, and likely southward expansion out of Beringia. There is growing evidence for persistence of conifer trees within Beringia through the last glacial phase (Anderson et al., 2006; Brubaker et al., 2005; Zazula et al., 2006), a strict requirement for persistence of these squirrels. In addition, red squirrels are currently widespread in Alaska, occurring within the northernmost conifers south of Anaktuvuk Pass at 68°N (Rausch, 1951).

The NPC lineage of *T. hudsonicus* exhibits relatively high nucleotide diversity and a broad distribution through this extensive archipelago, indicating persistence in one or more coastal refugia. *Tamiasciurus hudsonicus* joins a growing list of taxa for which evidence of refugial persistence exists, and reflecting long-term intact communities along the NPC (Cook and MacDonald, 2013). The mixed distribution of haplotypes coupled with niche predictions within both *T. douglasii*, and independently within mainland populations of *T. hudsonicus* suggests connectivity across much of their current range is recent and glacial phase ranges were more fragmented, particularly through western areas, supporting the concept of "refugia within refugia" (Shafer et al., 2010). The pattern is reversed in *T. fremonti*, in that the fragmented archipelago of sky-island populations represent current refugia considering many of these populations experienced much greater connectivity during the last glacial. However, niche predictions indicate effectively persistent isolation among the three major matrilineages of this species (Fig. S5 – LGM). The Sacramento Mountains were most isolated, while the Southern Rockies were partially isolated from sites further south due to alpine glaciers in southwestern Colorado, a significant set of barriers also hypothesized for other taxa (Barber, 2007).

5. Conclusions

Comprehensive molecular phylogenetic and ecological niche assessment of a widespread genus through North American forest ecosystems provides new insights on speciation across the Nearctic by highlighting how species diverge in response to long-term environmental variability. The obligate association of red squirrels with forests, coupled with relatively recent differentiation accompanied by gene flow, provides perspective on evolutionary responses to climate trends across broadly co-distributed taxa. Specifically within North America, southern peripheral populations of forest species may reflect long-term persistence through glacial cycling in cores habitat areas that is coupled with periodic elevational shifts. In other populations across the continent-wide range, periodic expansion or retraction to predictable refugial areas occur through latitudinal (and longitudinal) shifts as climate changes. In addition to focusing on the management of isolated and potentially shrinking peripheral populations, as contemporary environmental perturbations accelerate, it is critical that we also conserve highly dynamic regions of phylogeographic complexity within forested systems where evolutionary processes associated with gene exchange are influencing biodiversity in ways that are as yet much less clear.

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red squirrel specimen records on VertNet at the time of access for use in niche predictions.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ympev.2016.04.014.

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Revision of widespread red squirrels (genus: *Tamiasciurus*) highlights the complexity of speciation within North American forests

Andrew G. Hope [a,*], Jason L. Malaney [b], Kayce C. Bell [c], Fernando Salazar-Miralles [c], Andreas S. Chavez [d], Brian R. Barber [e], Joseph A. Cook [c]

[a] Division of Biology, Kansas State University, Manhattan, KS 66506, USA
[b] Department of Biology, Austin Peay State University, Clarksville, TN 37044, USA
[c] Department of Biology and Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM 87131, USA
[d] Museum of Vertebrate Zoology and Department of Integrative Biology, University of California-Berkeley, Berkeley, CA 94720, USA
[e] Biodiversity Institute, University of Wyoming, Laramie, WY 82071, USA

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Species tree estimation

ABSTRACT

Integration of molecular methods, ecological modeling, and statistical hypothesis testing are increasing our understanding of differentiation within species and phylogenetic relationships among species by revealing environmental connections to evolutionary processes. Within mammals, novel diversity is being discovered and characterized as more complete geographic sampling is coupled with newer multi-disciplinary approaches. North American red squirrels exemplify a forest obligate genus whose species are monitored as indicators of forest ecosystem condition, yet phylogenetic relationships reflecting evolutionary history within this genus remain tentative. Through testing of competing systematic and niche-based divergence hypotheses, we recognize three species, *Tamiasciurus douglasii*, *T. hudsonicus*, and *T. fremonti*. Our data provide evidence of regional differences in evolutionary dynamics and continental gradients of complexity that are important both for future management and for investigating multiple pathways that can lead to the formation of new species.

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1. Introduction

Understanding how the formation of species is shaped by common biogeographic and evolutionary processes (Hewitt, 2000; Taberlet et al., 1998) is a critical step for recognizing and conserving biodiversity (Riddle et al., 2008; Whittaker et al., 2005). Range-wide evolutionary assessments of species that incorporate both genetic and niche-based approaches provide critical perspectives on regional evolutionary and ecological differences in biodiversity. For instance, many vertebrate species associated with the boreal biome in North America have broad continent-wide distributions coincident with temperate and northern conifer forests (Arbogast and Kenagy, 2001), but these forests are now experiencing increased mortality (Allen et al., 2015), and regional declines (Coops and Waring, 2011; Gauthier et al., 2015) will likely continue to impact vertebrate communities. Geography and past climate have shaped the assembly of communities according to predictable biogeographic patterns that often reflect common evolutionary processes (Hampe and Petit, 2005). Northernmost contemporary populations frequently constitute a leading edge of expansion due to climate warming following the Last Glacial Maximum (LGM; ~the last 12 kyrs). However, high-latitude populations may have also experienced spatial and temporal stability if they persisted through the Last Glacial period (~130–12 ka) within one or more northern refugia (Brubaker et al., 2005; Hewitt, 1999; Lessa et al., 2003). Mid-latitude forest-associated populations often have multiple distinct lineages distributed longitudinally across the continent reflecting repeated isolation in discrete areas south of glacial-phase continental ice-sheets. However, the genetic signatures of independent histories among these lineages are often obscured at their distributional edges where they now overlap geographically (Atkinson et al., 2007; Hope et al., 2014a). Signatures of these complex histories of isolation and reconnection are often apparent along contact zones (Swenson and Howard, 2005) where dynamics of gene flow and interspecific interactions result in increased community complexity (Hewitt, 2000). Finally, peripherally isolated populations in southern and coastal regions

* Corresponding author at: Kansas State University, Division of Biology, 116 Ackert Hall, Manhattan, KS 66547, USA.
E-mail addresses: ahope@ksu.edu (A.G. Hope), jmalaney@gmail.com (J.L. Malaney), kayce.bell@gmail.com (K.C. Bell), f.salazarmiralles@gmail.com (F. Salazar-Miralles), aschavez@berkeley.edu (A.S. Chavez), bbarber4@uwyo.edu (B.R. Barber), cookjose@unm.edu (J.A. Cook).

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generally occur in patches of discontinuous forest. Peripheral populations can reflect either long-term isolation (⩾1 glacial phase; e.g., Cook et al., 2001, 2006) or more recent fragmentation of previously continuous habitat since the LGM (Galbreath et al., 2009). Such isolates often constitute important sources of genetic diversity for species (Channell and Lomolino, 2000) with high conservation value (Malaney and Cook, 2013).

A growing body of comparative genetic evidence indicates that evolutionary processes of diversification on a continental scale are repeatable both across taxonomic groups and through time, where cryptic diversity is discovered as additional groups are assessed, resulting in recognition of new species, or minimally, distinct evolutionary lineages (Hope et al., 2014a). Given that species descriptions are ongoing, even among mammals, current taxonomy frequently fails to adequately reflect the extent of evolutionary diversity or relationships among extant lineages (Patterson, 2000; Bickford et al., 2007), thus impeding effective management and conservation of fundamental components of biodiversity (Soltis and Gitzendanner, 1999; Hoberg et al., 2012). New toolsets are facilitating species discovery based on multi-locus sequence data (Knowles and Carstens, 2007). Concurrently, new statistical methods assess "species" limits, recognizing taxonomic or systematic arrangements that hold strongest support for actual relationships among distinct biological units (reviewed in Carstens et al., 2013). Both historical and ongoing gene flow between related species (e.g., Sullivan et al., 2014), however, present additional challenges to molecular systematic assessments.

The evolutionary history of North American red squirrels (genus *Tamiasciurus* Trouessart 1880) reflects the influence of long-term Quaternary climate cycles on continental patterns of diversification and community change (Arbogast and Kenagy, 2001). Periodic allopatry and divergence has been followed by episodes of reconnection and gene flow as climate cycled through glacial phases (Chavez et al., 2014). Simultaneously, some red squirrel populations, particularly peripheral ones, likely remained stable and isolated through extended glacial cycles. As such, systematic relationships, species limits, and taxonomy within this group remain tentative. Thorington and Hoffmann (2005) recognized three species: *Tamiasciurus douglasii* Bachman, 1839, distributed in forests from southern California and the Sierra Nevada northward through the Cascade and Coastal ranges; *Tamiasciurus hudsonicus* Erxleben, 1777, distributed across most of North America north of Mexico including multiple peripheral populations; and *Tamiasciurus mearnsi* Townsend, 1897, restricted within Baja California Norte, Mexico. Previous mitochondrial DNA (mtDNA) assessments (Arbogast et al., 2001; Barber, 2007) documented several divergent lineages, recounting a complex biogeographic history. Across these species, *T. hudsonicus* is paraphyletic with respect to *T. douglasii*, while *T. mearnsi* is minimally divergent from *T. douglasii* (Arbogast et al., 2001; Barber, 2007). In the American Southwest, populations of *T. hudsonicus*, including those on sky islands, potentially represent a third species (*Tamiasciurus fremonti*), based on genetic (Arbogast et al., 2001), behavioral, and morphological differences (Findley, 1961; Hardy, 1950). More recently, Chavez et al. (2014) largely corroborated these relationships with nuclear data, although mito-nuclear discord indicated historic introgression between populations of the Pacific Northwest. However, to date, no study has explicitly tested the validity of systematic relationships using a phylogenetic approach.

The North American red squirrel complex constitutes an excellent system for testing diversification hypotheses because their complex biogeographic history includes both physical (insular) and ecogeographic isolation of lineages, paraphyly, and gene flow. We present a multi-locus phylogenetic assessment of North American red squirrels and test three alternative hypotheses based on previous studies (Fig. S1). In the first hypothesis (H1 – Fig. 1) we apply the current taxonomy (Thorington and Hoffmann, 2005) of three species (*T. douglasii, T. hudsonicus,* and *T. mearnsi*). Considering that the specific status of *T. mearnsi* is tenuous (Arbogast et al., 2001), we test a second hypothesis (H2 – Fig. 2) proposed by Arbogast et al. (2001) that also posits three differently circumscribed species: *T. douglasii* (inclusive of *T. mearnsi*), *T. fremonti*, and *T. hudsonicus* (includes all currently recognized lineages except putative *T. fremonti*). Finally, we consider a third hypothesis (H3 – Fig. 3) treating nine well-supported mtDNA lineages as terminal taxa, all documented across independent studies (Arbogast et al., 2001; Barber, 2007; Chavez et al., 2014; this study). These three hypotheses require few assumptions and reflect realistic alternative relationships based on previous literature. Following genetic-based species delimitation, we incorporate niche modeling to assess geographic stability through time and ecological divergence among taxa. Finally, we use results from both multiple loci and climatic data to explore evolutionary complexity across North America, demonstrating different modes of speciation within this complex that are reflected more broadly among mammals. Critically, for forest ecosystem management, we identify areas that sustain key dynamic evolutionary processes as well as isolated populations needing further evaluation.

2. Methods

2.1. Study area, sampling and sequencing

We obtained specimens from museum collections that maximize geographic sampling through the known range of red squirrels (Figs. 1 and 3), including samples from all species and localities coincident with the geographic distribution of 22 of 28 subspecies (Hall, 1981). We used 252 specimens (Appendix A) including 40 *T. douglasii*, 209 *T. hudsonicus*, and 3 *T. mearnsi* from 109 general collecting localities (Fig. 3; 153 specific localities; Appendix A). Sequences for 123 individuals for at least 1 gene were retrieved from GenBank. We then sequenced 129 more specimens for 1–4 independent loci where a subset of 60 samples (including 34 specimens from Chavez et al., 2014) were represented by both mtDNA and nuDNA. In total we obtained 3192 bp of sequence data across all loci. Datasets included 771 base pairs (bp) of mtDNA cytochrome-*b* gene (Cytb; $n = 252$), 449 bp of the glutamate decarboxylase 2 gene (intron 1; GAD2; $n = 60$), 666 bp of the ganglioside-induced differentiation-associated protein 1 gene (intron 1; GDAP1; $n = 58$), 630 bp of the UPF0351 protein C9orf32 gene (intron 1; METTL11A; $n = 59$), and 676 bp of the prolyl 4-hydroxylase alpha-2 subunit precursor gene (intron 1; P4HA2; $n = 60$).

We extracted genomic DNA from tissue (stored at −80 °C or ethanol preserved) through standard salt extraction, followed by PCR amplification and cycle sequencing with ABI BigDye v3.1 (Applied Biosystems, Foster City, California) following protocols of Platt et al. (2007). Primers for Cytb were MVZ05/MVZ16 (Smith and Patton, 1993). Other primers are listed in Chavez et al. (2014). We conducted automated sequencing of complimentary strands using the Applied Biosystems 3110 DNA sequencer at the University of New Mexico.

We edited and aligned sequences in Sequencher v4.8 (Genecodes, Ann Arbor, Michigan) and verified visually. We translated protein-coding sequences for Cytb to amino acids and examined them for internal stop codons, rates of transition/transversion changes, and relative 1st, 2nd, and 3rd position changes in codons that might indicate a Numt. None was found. We compared complementary strands of DNA and deposited contiguous sequences in GenBank (Appendix A). We inferred alleles of heterozygotes using Phase (Stephens et al., 2001), by accepting results with a

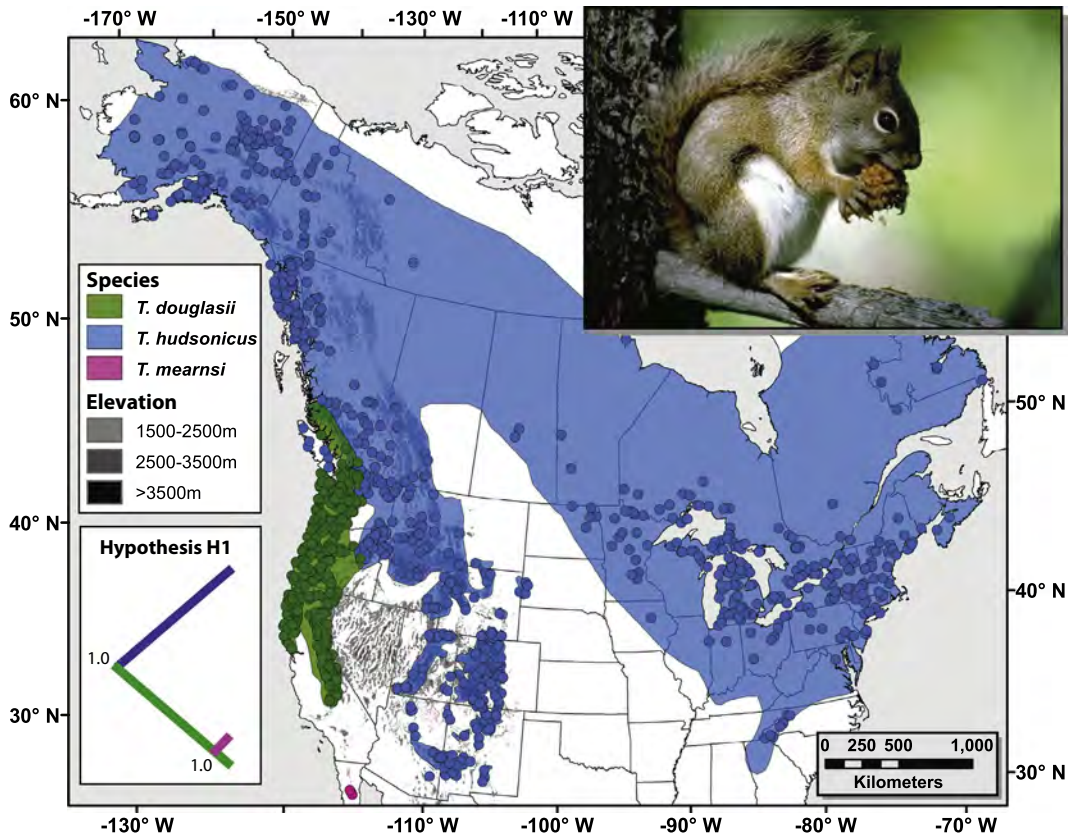

Fig. 1. Distribution and current taxonomy of North American tree squirrels (*Tamiasciurus*). Data points indicate localities of all samples considered for niche analyses. Inset provides the results of a *BEAST species tree analysis (including empirical topology and nodal support values) considering systematic hypothesis H1 with three species as *T. hudsonicus*, *T. douglasii*, and *T. mearnsi*. Downloaded from Wikipedia March 2015. Author: Cephas. This file is licensed under the Creative Commons Attribution-Share Alike 3.0. Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled *GNU Free Documentation License*.

probability >90%, using a burn-in of 10,000 iterations and a run length of 10,000 iterations (McCormack et al., 2011). Among 5 runs, we retained results from the run with best goodness-of-fit to an approximate coalescent model, resulting in 2 nuclear haplotype sequences or alleles per individual, using only 1 allele per individual (chosen randomly) for analyses.

2.2. Multi-locus gene trees and evolutionary rates

We estimated independent genealogies and haplotype networks for all loci. We determined DNA substitution models for each locus using MrModeltest v2.3 (Nylander, 2004) under the Akaike Information Criterion. We performed Markov chain Monte Carlo (MCMC) searches in MrBayes v3.1 (Ronquist and Huelsenbeck, 2003), incorporating the short-branch method (Marshall, 2010). Stationarity of MCMC runs was assessed in Tracer v1.5.0 (Rambaut and Drummond, 2007). Phylograms were midpoint rooted and visualized with posterior probabilities >0.75 included in FigTree v1.3.1 (Rambaut, 2009). For all loci, we assigned haplotypes using DnaSP v5 (Librado and Rozas, 2009). Median-joining haplotype networks for all loci were constructed in Network v4.610 (Bandelt et al., 1999). To assess the timing of cladogenesis and demographic changes among lineages, we calculated average and lineage-specific evolutionary substitution rates utilizing a time to coalescence of the entire genus as estimated by Chavez et al. (2014). In BEAST v1.6.1 (Drummond and Rambaut, 2007), we produced a chronogram based on the Cytb locus by fixing the time to most recent common ancestor (T_{MRCA}) for all samples at 0.4229 Ma (normal distribution, standard deviation 0.1; Chavez et al., 2014), applying a relaxed clock: uncorrelated log-normal, and set the substitution rate to be estimated. We used the HKY + G model of substitution, empirical base frequencies, partitioned into three codon positions, and a constant population size tree prior. Three separate runs of 100 million iterations were run, sampling trees to file every 1000 iterations. To retrieve mean lineage-specific rates for each nominal lineage recovered from the Cytb chronogram, we weighted all branch specific rates by branch length (Hope et al., 2014b) according to the equation $\sum$ (rate $\times$ length)/$\sum$ (length).

2.3. Mitochondrial diversity and demographics

Genetic diversity analyses for Cytb used all available red squirrel sequences, performing analyses separately for major lineage assignments (Table 1). In DnaSP, for each group we assessed genetic diversity including number of segregating sites (S), haplotypes (h), haplotype diversity (Hd), nucleotide diversity (π), and tested for demographic expansion by calculating Tajima's D (Tajima, 1989) and $R2$ (Ramos-Onsins and Rozas, 2002).

To calculate population size change through time, we implemented the coalescent Bayesian Skyline Plot (BSP) tree prior in BEAST. Results of Bayes factor tests to determine the best clock model indicated no significant difference between strict and relaxed clocks for any lineage, so we utilized a strict clock, and ran MCMC analyses (length of chain = 100 M logging trees every

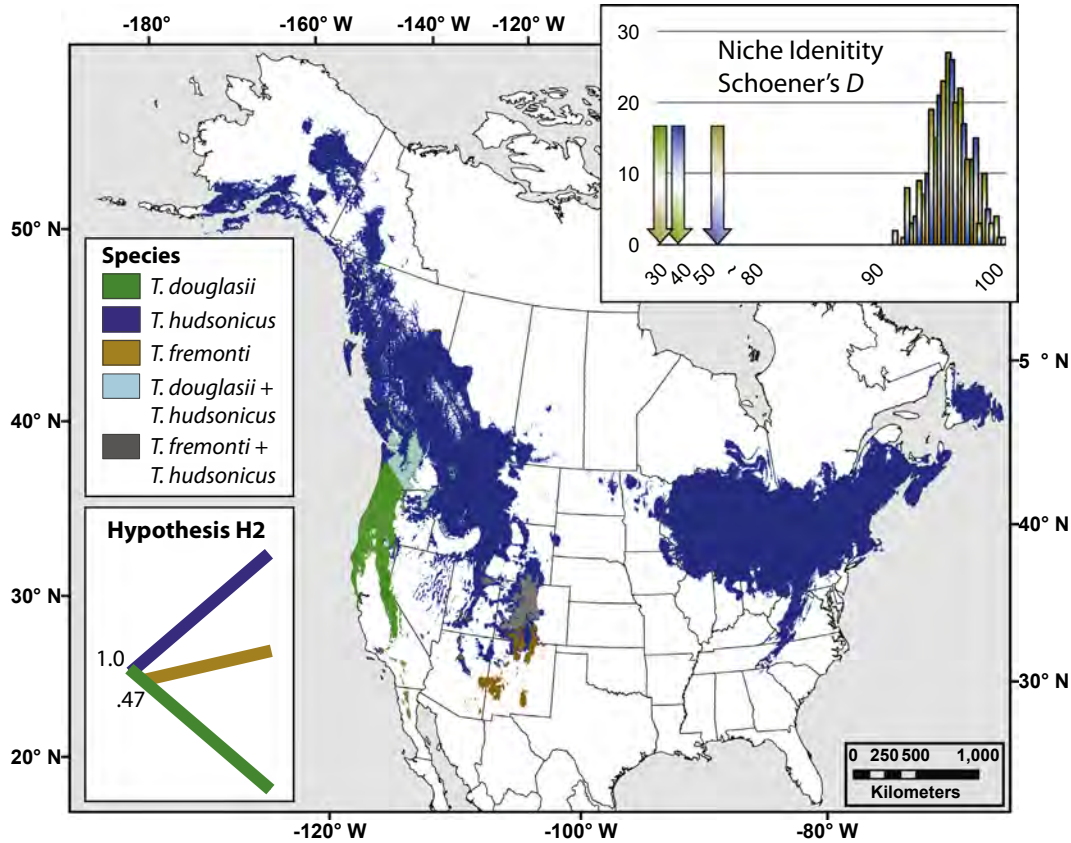

Fig. 2. Bioclimatic envelope models for North American red squirrels considering three species according to systematic hypothesis H2 as *T. douglasii* (green), *T. fremonti* (brown), and *T. hudsonicus* (dark blue). We used model selection and applied a minimum of 90% of training samples as our threshold for each species. Potential geographic overlap between species is depicted with intermediate colors (cyan between *T. hudsonicus* and *T. douglasii*, and gray between *T. hudsonicus* and *T. fremonti*). Left inset provides the results of *BEAST species tree analysis considering H2, including empirical topology and nodal support values. Top inset shows results of niche identity test, where all pairwise comparisons indicate significant ecological differentiation between species. The histogram provides expected niche overlap when pairwise species are pooled and randomized, and arrows indicate empirical niche overlap between species (Schoener's *D*). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

1000), assigning lineage-specific rates calculated from the Cytb chronogram.

2.4. Systematic scenarios

Using a model comparison technique that applies Bayes Factors (2*ln*Bf) or Akaike information criterion through Markov chain Monte Carlo analysis (AICM) to test between alternative scenarios of species delimitation (Aydin et al., 2014; Grummer et al., 2014) allows flexibility for alternative hypotheses and is robust to systems where historical introgression is suspected (Grummer et al., 2014). We performed model comparison tests of alternative systematic hypotheses among designated lineages of North American red squirrels considering all loci within a species-tree framework implemented using *BEAST (Heled and Drummond, 2010). Because *BEAST accommodates different numbers of gene copies for each taxon, we included all samples per lineage that were sequenced for more than a single locus.

We performed Bayes Factor and AICM pairwise tests of alternative hypotheses (Table 2; Fig. S1). All hypotheses considered samples ($n = 60$) representing various combinations of the nine well-supported monophyletic mtDNA (Cytb) lineages: Two widespread lineages (Continental and Northwestern), a Western lineage (combining *T. douglasii* and Baja California samples unless otherwise noted), Vancouver Island, Central Rockies, North Pacific Coast, Sacramento Mountains (NM), Southern Rockies, and Southwestern Sky Islands (Fig. 1). Despite a high likelihood of ongoing gene flow within and among certain lineages, all were included to assess relative nodal support for clade relationships considering multiple loci under three different hypotheses. Hypothesis H1 considered the currently assigned taxonomy (*T. douglasii*, *T. hudsonicus*, and *T. mearnsi*; Fig. 2). Hypothesis H2 considered three species hypothesized by Arbogast et al. (2001): *T. douglasii* (including *T. mearnsi*), *T. fremonti* (Southern Rockies, Sacramento Mountains, and Southwestern Sky Island), and *T. hudsonicus* (Continental, Northwestern, Southeast Alaska, Vancouver Island and Central Rockies). Hypothesis H3 considered all Cytb lineages as independent "species". All hypotheses were compared statistically using both all loci and only nuclear loci.

We produced a separate traits file indicating lineage assignments for all samples under each hypothesis. In BEAUti, for each hypothesis, we unlinked datasets for each locus across all partitions, assigned substitution models by locus, and applied empirical base frequencies. We applied a relaxed clock: uncorrelated lognormal to Cytb as the ucld standard deviation of the rate for this gene when analyzed independently significantly deviated from zero, but assigned a strict clock to nuclear loci to reflect lower divergence over the evolutionary timeframe investigated. We chose a Yule tree prior with piecewise linear and constant root and assigned proper ploidy to each locus. Two independent runs for each hypothesis used MCMC chains of 100 million generations sampling trees every 10,000.

In Tracer, we ran model comparisons to identify the hypothesis that best explained the data considering marginal likelihood

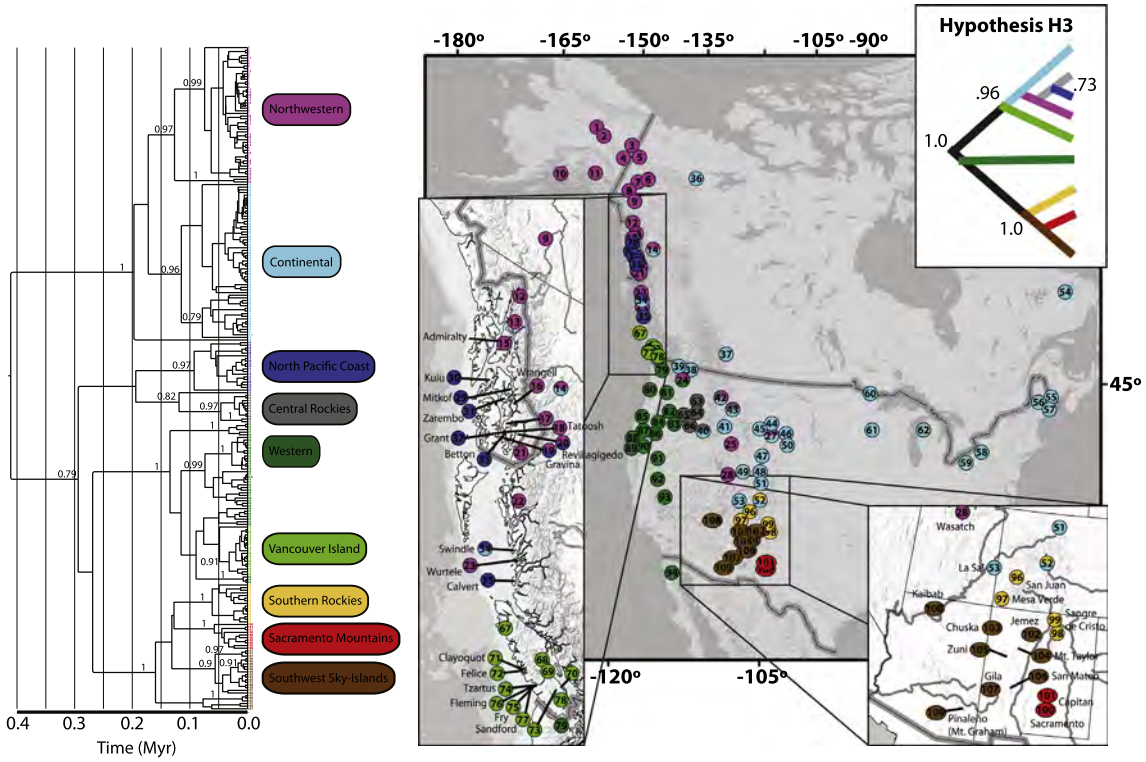

Fig. 3. Left – Chronogram of evolutionary relationships among North American red squirrels (*Tamiasciurus*) based on 771 bp of the mtDNA Cytochrome b gene with a root coalescence estimate from Chavez et al. (2014). Phylogeny estimation was performed in BEAST, providing both posterior probability nodal support values (left of node) and coalescence times (millions of years; italics, right of node). The topology is presented as ultrametric and proportional to an evolutionary timeline (bottom) that extends from the present (right) to the past (left). Tip labels indicate general collecting localities (Appendix A). Major lineages are color coded and coincident with geography. Tip labels indicate sampling localities. Right – Map of the study area indicating general specimen localities for samples of North American red squirrels included in the present study. Locality numbers correspond to those listed in Appendix A. Left inset provides finer detail of localities along the North Pacific Coast. Bottom-right inset provides finer detail of localities within the Southwestern region. Localities are colored according to major mtDNA lineages. Circles with multiple colors indicate general localities where multiple mtDNA lineages are sympatric. For insets, insular populations are labeled by island or mountain range. Top inset provides the results of a *BEAST species tree analysis (including empirical topology and nodal support values) considering systematic hypothesis H3 with nine independent taxa color-coded according to mtDNA lineages. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Genetic polymorphism and demographic statistics considering 771 bp of the mtDNA Cytochrome b gene among major North American red squirrel lineages. Abbreviations include *n* = sample size; *S* = number of segregating sites; *h* = number of haplotypes; *Hd* = haplotype diversity; π = nucleotide diversity; *D* = Tajima's *D* (with associated *P*-value); *R2* = Ramos-Onsins and Rozas *R2* (with associated *P*-value); μ = lineage-specific substitution rate (percent per million years) considering rates weighted by branch lengths for each lineage from the Cytochrome b BEAST chronogram. The rate given for all lineages combined was calculated in BEAST using a root calibration of 0.4229 Myr (HPD: 0.2979–0.5538; Chavez et al., 2014). N/A = not applicable. Bold values are statistically significant at $P < 0.05$.

	n	*S*	*h*	*Hd*	π	*D*	*P*(*D*)	*R2*	*P*(*R2*)	μ
All	252	134	142	0.982	0.0181	N/A	N/A	N/A	N/A	5.23
Central Rockies	11	4	4	0.600	0.0015	−0.542	0.324	0.142	0.107	5.14
Continental	60	41	34	0.866	0.0045	**−2.167**	**0.001**	**0.046**	**0.000**	5.20
Northwestern	52	45	32	0.924	0.0031	**−2.593**	**0.000**	**0.022**	**0.000**	5.35
North Pacific Coast	20	15	16	0.963	0.0040	−1.192	0.132	0.088	0.056	5.03
Sacramento Mountains	10	11	7	0.933	0.0035	−1.407	0.096	0.124	0.056	5.26
Southern Rockies	15	14	10	0.924	0.0035	−1.509	0.064	**0.079**	**0.000**	5.42
Southwestern Sky Islands	22	17	12	0.905	0.0037	−1.413	0.062	**0.073**	**0.011**	5.26
Vancouver Island	19	8	7	0.544	0.0012	**−2.022**	**0.001**	**0.084**	**0.002**	5.21
Western	42	35	26	0.962	0.0067	−1.325	0.074	0.065	0.059	5.25

estimates of competing hypotheses using both 2*ln*Bf and 2AICM scores. Scores were ranked for each hypothesis only with respect to the "best" hypothesis (that with the marginal likelihood estimate closest to zero). As described in Grummer et al. (2014), and based on the recommendations of Kass and Raftery (1995), the strength of support of 2*ln*Bf for the best hypothesis (labeled as N/A) compared with competing hypotheses was as follows: 0–2 means no significant support; 2–6 means positive support for the best hypothesis (N/A) over this competing scenario; 6–10 means strong support for the best hypothesis; and >10 means decisive rejection of the competing hypothesis compared with the best hypothesis. As in Grummer et al. (2014), we recognized distinct lineages from hypotheses (topologies) where 2*ln*Bf support for the leading topology was >10 in pairwise comparisons with competing hypotheses. Similarly for AICM which equates using two times the sample mean log likelihood, we use a cutoff of >20 for 2AICM (multiplied by 2 for consistency with Bayes Factor methods).

Table 2
AICM and Bayes Factor (2*ln*Bf) results considering marginal likelihood estimates from alternative species-tree hypotheses of relationships among major lineages of North American red squirrels (see Fig. S1 for scenario topologies). The hypothesis receiving the best marginal-likelihood score is indicated by N/A. 2AICM and 2*ln*Bf scores for other scenarios reflect comparative strength of the best supported hypothesis, where for 2*ln*Bf a score of 0–2 means "not worth more than a bare mention", 2–6 means "positive" support for the best hypothesis over that alternative, 6–10 provides "strong" support, and >10 means "decisive" support in distinguishing between best and competing hypotheses (after Kass and Raftery, 1995). For 2AICM scores, we consider >20 as decisive, 12–20 as strong, and 4–12 as positive support for the best hypothesis over that alternative. Hypotheses were analyzed considering all five loci (both mtDNA and nuDNA) and using only the four nuclear loci.

Scenario	Description	All five loci		Four nuDNA loci	
		2AICM	2*ln*Bf	2AICM	2*ln*Bf
H1	3 species as currently described (*T. douglasii*, *T. hudsonicus*, *T. mearnsi*)	N/A	10.28	5.72	10.74
H2	3 species as per Arbogast et al. (2001; *T. douglasii*, *T. hudsonicus*, *T. fremonti*)	27.85	N/A	N/A	N/A
H3	All lineages considered separately	104.10	22.76	31.70	16.06

2.5. Bioclimatic envelope modeling

We used bioclimatic envelope modeling (BEM, Araújo and Peterson, 2012) to characterize occupied distributions and reconstruct paleodistributions of each species. We used these niche-based tests as an independent perspective of ecological divergence among putative species using a three-step approach: (1) reconstruct contemporary distributions and project (transfer) the final model to ancestral climate conditions (i.e., mid-Holocene and LGM); (2) assess spatial overlap of predicted distributions for all periods; and (3) conduct niche identity tests using geographic-based approaches (Warren et al., 2008, 2010).

2.5.1. Occurrence and environmental data

BEMs are often constructed from two forms of data: occurrence records and environmental layers. We downloaded all available records of North American red squirrels from VertNet (accessed February 2015) and conducted a series of screening and filtering steps to reduce bias. We removed all samples with a georeferenced error >5 km, those that failed to provide an estimate of error, and those that were outside the known distribution of *Tamiasciurus*. We also removed samples prior to 1940. To reduce spatial autocorrelation, we used a custom aggregated reduction technique (Fourcade et al., 2014; Warren et al., 2014) by retaining a single random sample within 10 km^2 radius and discarding other spatially redundant locations.

To assess lineage-based distributional overlap and test for recent niche divergence among evolutionarily independent groups we used mtDNA haplotypes to quantify areas occupied by lineages. First, we added a minimum convex polygon in ArcGIS v10.2 to each lineage-based set of points and applied a 200 km buffer to assign all points within each polygon to respective mtDNA lineages. We then reassigned mtDNA samples to putative species identified from the best model in tests of evolutionary hypotheses.

The geographic extent of species is an important consideration when using correlative models (Barve et al., 2011). However, the total extent of *Tamiasciurus* is likely too broad considering our goals of pairwise tests between geographically limited species. Based on the geographic distribution of putative species, we divided the study area using the three regional clades (systematic hypothesis H2; Table 1; Fig. S1) and delimited their extents to 100 km beyond the N/S and E/W extremes of each distribution.

Next, we generated bias files for each species to optimize background and occurrence point selection within study extents. Bias files are frequently used in correlative modeling to avoid oversampling and can offset effects of geographic biases often associated with coordinate-based data, decreasing commission (false-positive) error rates (Anderson and Raza, 2010; Barve et al., 2011; Merow et al., 2013). We used SDMToolBox v1.1c (Brown, 2014) to generate the bias files for each species, using the "Sample by Buffered Local Adaptive Convex-Hull" tool that limits background points (Thuiller et al., 2009; Barbet-Massin et al., 2012) and set the buffer distance to 75 km and alpha parameter to four.

We used 19 bioclimatic (temperature and precipitation) variables from the WorldClim database to quantify ecological tolerances of each lineage. These landscape-level data are often useful for assessing both current and paleodistributions (Malaney and Cook, 2013; Waltari and Guralnick, 2009; Waltari et al., 2007), and also for assessing Grinnellian-based niche divergence (McCormack et al., 2010). Then, we identified tightly correlated ($\geqslant$0.80) and removed redundant variables, favoring those more temporally inclusive (e.g., bio11 – mean temperature of the coldest quarter versus bio6 – minimum temperature of the coldest month) or relevant to squirrel ecology (e.g., cone mast is often linked to seasonal conditions; bio15 – precipitation seasonality).

2.5.2. Correlative modeling

We used MaxEnt version 3.3.3e (Phillips and Dudik, 2008) due to superior performance over other correlative modeling approaches (Elith et al., 2006; Peterson et al., 2007) and ability to provide statistical comparisons among models (Elith et al., 2011; Merow et al., 2013). MaxEnt uses presence data in comparison with random background samples to estimate species distributions (Elith et al., 2011; Guillera-Arroita et al., 2015; Merow et al., 2013), but is optimized with multiple default settings that require testing prior to modeling to enhance model performance (Anderson and Gonzalez, 2011). Consequently, we conducted criterion-based model selection (Burnham and Anderson, 2002; Warren and Seifert, 2011) by assessing different combinations of the feature class types (FC) and regularization multipliers (RM) using ENMTools v.1.4.4 (Warren et al., 2010). We constructed single models for each species by applying alternate FCs (e.g., L – linear; LQ – linear and quadratic; H – hinge; LQH – linear, quadratic, and hinge; LQHPT – LQH, product, and threshold) and alternate RMs ranging from 0.01 to 5.0 at 0.5 intervals. In sum, we tested 55 alternate models for each species (5 FCs $\times$ 11 RMs), identifying optimum model settings using corrected Akaike information criterion (AICc).

We then conducted final modeling for each species using 20 replicates, log-scale outputs, and set number of iterations to 5 k, keeping the default convergence threshold (=0.00001). During replicate models, we applied the bias file for background sampling, retained 20% of presence localities as a training dataset, and used subsampling run type (jackknife approach) because of small sample sizes for some mtDNA lineages (Pearson et al., 2007; Shcheglovitova and Anderson, 2013). Standard deviations across all replicates were minor.

MaxEnt produces a set of continuous surfaces and we used the mean of replicated models to represent relative suitability/likelihood (Guillera-Arroita et al., 2015; Richmond et al., 2010). To assess differences between high suitability for each species, we constructed a single raster by calculating the difference between the continuous mean logistic outputs of comparative lineages (DiffAB = species A – species B). Further, we created a binary distribution of suitable and unsuitable areas using the equal training sensitivity and specificity logistic threshold for the spatial projection of final models (Pearson et al., 2007) and used the

threshold-applied distributions to characterize paleodistributions and assess distributional shifts (see below).

2.5.3. Paleodistributions

We reconstructed paleodistributions of individual lineages to understand the history of geographic distributions, frequently yielding insights of ancestral areas as well as regions of historic admixture (Pelletier et al., 2015). Specifically, we projected predictions for the mid-Holocene (contemporary models; i.e., Younger Dryas) and late-Pleistocene (i.e., Last Glacial Maximum – LGM). Considering many North American mammals have shifted distributions (Malaney and Cook, 2013; Lessa et al., 2003), we expanded the spatial extents through past timeframes by 500 km to include areas nearby that might have been historically occupied by ancestral populations. Further, we validated paleodistribution reconstructions with fossil records obtained from FaunMap database (accessed March, 2015). We then assessed spatial overlap among clades using techniques analogous to contemporary overlap measurements.

2.5.4. Model-based niche divergence

To assess the degree of niche overlap among the major clades, we used the G-space niche-identity test using the *D* statistic (Schoener, 1968; Warren et al., 2008), which ranges from 0 (discordant) to 1.0 (identical). The niche-identity test is used to assess whether measured overlap is significantly different (one-tailed test) from an underlying null expectation. This approach randomized samples from each lineage pair using 100 pseudoreplicates for each pairwise test.

3. Results

3.1. Gene trees and evolutionary rates

A previously calculated age for the T_{MRCA} of all North American red squirrels of 0.4229 Myr (Chavez et al., 2014) provided an average mutation rate of 5.23% per million years (10.46% divergence rate) for the Cytb dataset (Table 1). Substitution rates ranging from 5.03% to 5.46% per million years were recovered for nominal lineages within the red squirrel Cytb genealogy (Table 1). The chronogram indicates nine well-supported, spatially-structured lineages (Fig. 3). Two lineages exhibit broad distributions, often within previously glaciated areas, indicative of post-glacial population expansion. The Continental lineage is broadly distributed across North America whereas the Northwestern lineage is coincident with the Rocky Mountain cordillera. These two lineages together form a well-supported clade distinct from all other North American red squirrels. Other well-supported lineages include the Central Rockies with a limited distribution within the inland forests of Idaho, western Montana, and eastern Oregon. The North Pacific Coast (NPC) lineage is only distributed on islands of the Alexander Archipelago (Betton, Grant, Gravina, Kuiu, Mitkof, Revillagigedo, and Zarembo islands), and in British Columbia on Calvert and Swindle islands (Fig. 3). Mitochondrial signatures indicative of both NPC and Northwestern lineages occur on Gravina and Revillagigedo islands of the southern Alexander Archipelago. The Northwestern lineage also occurs on Admiralty (introduced), Tatoosh, and Wrangell islands. The Western mtDNA lineage is paraphyletic with respect to Vancouver Island (due to recognized mito-nuclear discord) and is distributed from Baja California (*T. mearnsi*) north to southern British Columbia. Finally, substructure within the well-supported Southwestern clade includes lineages associated with the Sacramento Mountains of New Mexico, the Southern Rockies of Colorado and northern New Mexico, and two paraphyletic lineages associated with the Southwestern Sky Island archipelago (Fig. 3).

The initial dichotomy within the Cytb chronogram is dated to ~400 ka. Continental and Northwestern lineages were estimated to have split at 200 ka. Coalescence of all Southwestern lineages is coincident with the Illinoian glacial period (~160 ka) although initial divergence from other squirrel lineages is dated >250 ka. Coalescence of most terminal lineages is <100 ka.

Independent nuclear genealogies were less well resolved although Western haplotypes were consistently private across all loci (Fig. S2). All well-supported mtDNA lineages exhibited at least one private nuclear haplotype. Continental and Northwestern haplotypes were closely related, as were those of all Southwestern lineages. Within the Southwestern Sky Island lineages, the federally endangered Mt. Graham (Pinaleño Mountains) population exhibited private haplotypes over all loci except one (Fig. 3; Fig. S2).

3.2. Diversity and demographics

Mitochondrial DNA haplotype and nucleotide diversity were lowest for the Vancouver Island lineage and highest for the Western lineage (Table 1). Within the Continental lineage, samples collected from western and eastern North America were divergent (Fig. 3). Only Continental and Northwestern lineages exhibited consistent signals of demographic expansion over multiple tests, a finding also supported by star network topologies (Table 1; Fig. S2). BSPs for these lineages indicated the most dramatic population growth coincident with post-glacial expansion (Fig. S3). BSPs for both the NPC and Western lineages also indicated significant population growth but non-significant demographic expansion, suggesting *in situ* growth through the late-glacial and Holocene timeframes. Skyline changes for Central Rockies, Sacramento Mountains, Southern Rockies and combined Southwestern Sky Islands lineages failed to reach the 95% highest probability distributions indicating minimal population growth (Fig. S3). Uncorrected pairwise mtDNA genetic distances between the 9 major lineages ranged from 0.84% to 3.48% sequence divergence with highest divergence between Northwestern and Southern Rockies lineages.

3.3. Systematic hypotheses

All species-tree topologies strongly supported the presence of multiple species and lack of reciprocal monophyly of *T. hudsonicus* as currently recognized. Each systematic hypothesis is reported in conjunction with the geographic ranges of nominal taxa according to respective hypotheses shown on maps, and these phylogenies reflect the results of species-tree analyses, including relative branch lengths, empirical topologies, and posterior probabilities at nodes (Figs. 1–3, S1). When Southwestern lineages were considered as a separate species, they were consistently less divergent from *T. douglasii* than from the remaining lineages of *T. hudsonicus*, although low posterior probabilities coupled with basal coalescences support the possibility of a radiation of three species through initial fragmentation, dating to the pre-Illinoian (~400 ka). Based on all loci, Bayes Factor model comparisons decisively supported Hypothesis H2 as the best systematic arrangement (Fig. S1; Table 2). AICM comparisons using only nuclear loci also supported H2 above other scenarios. Hypothesis H2 provides highest likelihood for true species relationships, considering all species tree estimates, and reflects three species. As also reflected by divergent ecological associations, we recognize the Douglas squirrel, *T. douglasii* consisting of the Western lineage, the southwestern red squirrel, *T. fremonti* Audubon and Bachman, 1853, consisting of the Southern Rockies, Sacramento Mountains,

and Southwestern Sky Islands lineages, and the American red squirrel, *T. hudsonicus* consisting of the remaining 5 lineages.

3.4. Bioclimatic envelope modeling

3.4.1. Niche variables and occurrence points

We obtained 20 niche variables that exhibited varying levels of importance and correlation across the study region (Table S1). For occurrence points, we obtained a total of 1160 *T. douglasii* (including *T. mearnsi*), and 3413 *T. hudsonicus* records. After processing (screening, partitioning, thinning, and clipping), we identified 279 *T. douglasii* and 740 *T. hudsonicus* records for reconstructing distributions and conducting niche tests. We then assigned 59 of the *T. hudsonicus* records from the Southwest as *T. fremonti* using genetic data as a guide.

3.4.2. Model performance

We found that optimized settings reflected a best-fit for our study system using model selection that increased the regularization penalty, simplified features, and reduced the overall dimensionality of final models. MaxEnt performed well with mean training AUC >0.85 for all analyses, often a positive indication of optimized models. Randomly withheld test data were predicted significantly better than random with AUC >0.90 for all analyses (Table 3) and AUC standard deviations all <0.05. Threshold-dependent approaches yielded results with low omissions and significantly better omission rates from threshold-dependent predictions than from random predictions.

3.4.3. Current distributions and overlap

Distributions of North American red squirrels were best predicted ($\geqslant$10% variable importance) by three variables for each species and six variables total (Table 3). For *T. douglasii*, >73% of the variation was accounted for by winter precipitation (bio19 = 39.7%), precipitation seasonality (bio15 = 20.0%), and isothermality (bio3 = 13.5%). For *T. hudsonicus*, over 50% variable importance was due to isothermality (31.3%) and winter precipitation (21.5%), with mean annual temperature (bio1 = 12.7%) the third most important, totaling 79.3%. The three most important variables (65.5%) for *T. fremonti* included average summer temperature (bio5 = 50.0%), temperature seasonality (bio4 = 13.5%), and like other species, winter precipitation (15.8%).

Current distributions predicted for each species overlap (Fig. 2), with *T. hudsonicus* sharing predicted range with *T. douglasii* in the Pacific Northwest (overlap = 77,754 km^2) and with *T. fremonti* in the Southern Rocky Mountains (overlap = 71,408 km^2).

3.4.4. Paleodistributions

We document distributional change for all species between the LGM, mid-Holocene, and present. Even after applying thresholds of currently occupied distributions and projecting to historical conditions (i.e., mid-Holocene and LGM), most fossil records (>80%, Figs. S4–S6) were accurately predicted. Predicted ancestral areas (LGM) for *T. douglasii* were centered on northern California (Fig. S4) with isolated regions in southern California and northern Baja, and although generally further south, total predicted area was only slightly larger than mid-Holocene and today. Predicted distributions shifted to higher elevations and more northern latitudes during the Holocene and are most restricted in total range at present. For *T. fremonti*, LGM distributions were projected to be >2$\times$ the extent of present distributions, with a retraction to higher elevations during the Holocene rather than a shift across latitude (Fig. S5). For *T. hudsonicus*, latitudinal shifts appear to have been the dominant change from LGM to mid-Holocene and today (Fig. S6). Potential LGM occupation included ancestral regions along the North Pacific Coast and within eastern Beringia (Alaska).

3.4.5. Stable regions for squirrels

By overlaying predictions from all models, we identified stable regions for all three species, although eco-geographic stability varied. For *T. douglasii,* three regions have remained relatively stable between the LGM and today, including medium elevations in the Sierra Nevada of eastern California, the Coast Ranges in northwestern California and Oregon, and high elevations of southern California and Baja Mexico. The total combined stable area for *T. douglasii* is ca. 69,000 km^2 (20.8% of the present distribution). For *T. fremonti*, we detected three temporally stable areas largely coincident in extent with the current range, including the Rocky Mountains of Colorado and New Mexico, the Sacramento Mountains in southeastern New Mexico, and the Mogollon Mountains of New Mexico and Arizona. When combined, these stable areas for *T. fremonti* totaled ca. 111,000 km^2 (62.9% of the present distribution). In contrast to *T. douglasii* and *T fremonti, T. hudsonicus* had few consistently occupied regions between the LGM and today totaling <80,000 km^2, a very small proportion of the total potential range in any timeframe (2% of present distribution). Whereas historic areas are largely coincident with temporally stable regions for *T. fremonti*, and slightly less so for *T. douglasii*, past predictions for *T. hudsonicus* are largely independent of interglacial (recent) distributions.

3.4.6. Niche identity

Despite large areas of potential distributional overlap between species (Fig. 2), the background test of niche identity indicated that each squirrel species occupies distinct ecospace when compared to expected niche overlap from pooled samples. All three species have non-identical niches and distributions (Schoener's *D* values $\leqslant$0.50).

Table 3
Relative importance of niche model variables. During modeling, we conducted 20 replicates, retained 20% of samples for training, and applied optimized parameters from model selection. The training, test, and standard deviation of AUC (=Area Under Curve) scores are measures of model performance. Below the AUC metrics are the relative contributions of variables. Variables shown contributed >10% to each model and were used for ecological interpretation, corresponding to the top three variables in each model. Symbols reflect results of the jackknife test of variable importance showing the highest gain when used in isolation ($*$), the variable that decreased the gain most when omitted (#), and the variable with the highest permutation importance ($).

AUC/variable	*T. douglasii*	*T. fremonti*	*T. hudsonicus*
Test AUC	0.942	0.911	0.905
AUC SD	0.008	0.047	0.012
Annual Temperature (Bio1)			12.7*
Isothermality (Bio3)	13.5		31.3$^{\#,\$}$
Temperature Seasonality (Bio4)		13.5	
Summer Temperature (Bio5)		50.0$^{*,\$}$	
Precipitation Seasonality (Bio15)	20.0$^{\#,\$}$		
Winter Precipitation (Bio19)	39.7*	15.8$^{\#}$	21.5

4. Discussion

This comprehensive phylogenetic assessment of the North American red squirrels provides a more complex interpretation of speciation within these forest obligate species and characterizes processes that also influence other species of this increasingly fragmented community. Congruence across species hints at fundamental ecogeographic variability on a continental scale that has predictable evolutionary consequences. Three main dynamics emerge from our analyses.

The first dynamic reflects evolutionary complexity across North America among forest dwelling species, with a dichotomy that contrasts minimal evolutionary structure in eastern North America (a single widespread lineage for red squirrels) with comparatively complex structure in the west (three species and multiple lineages). This east/west split reflects the Mississippi discontinuity as now reported across multiple other taxa (e.g., Soltis et al., 2006), with the Great Plains Ecoregion serving as a major barrier between east and west, and a gradient of increasing genetic complexity found within temperate forested biomes from east to west. Within the west, three geographic centers of diversity exist as reflected by *T. douglasii* in westernmost generally mesic forests, *T. fremonti* distributed through the Southwest, and *T. hudsonicus* with an extensive distribution through remaining interconnected forests.

The second dynamic reflects regional variability in spatial responses of species to long-term climate trends. Both genetic demographic analyses and niche predictions indicate relative stability through the southwest region with over 60% of current niche for *T. fremonti* consistently predicted as suitable through all recent (Late Quaternary) climate phases. By contrast, all lineages within *T. hudsonicus* except for the Central Rockies exhibit significant signals of recent demographic expansion and virtually no persistent niche space through timeframes. Dramatically different histories for *T. hudsonicus* and *T. fremonti* reflect alternate modes of diversification. In the southwest, *T. fremonti* is the product of ancient peripatric isolation and subsequent divergence accompanied by periodic fragmentation/reconnection at local scales. In contrast, glacial and interglacial phase distributions of *T. hudsonicus* are non-overlapping, and such vast spatial displacement likely reflects repeated population extirpations as leading edge expansions and contractions predominate through time, resulting in species-wide range shifts. Across the continent-wide distribution of *T. hudsonicus,* broad-scale fragmentation and range contractions with subsequent differentiation in multiple isolated areas, generated high overall genetic diversity. *Tamiasciurus douglasii* exhibits an intermediate history with reduced glacial–interglacial phase displacement and medium-term persistence of populations.

The third major dynamic is relatively rapid radiation of three species despite repeated and ongoing gene flow, reflecting again high regional complexity in western North America and climate phase expansion–contraction dynamics. Similar episodes of rapid diversification are being uncovered in other forest-dwelling mammals with shared geographic distributions (e.g., Shafer et al., 2010). For instance, both the *Sorex cinereus* complex and *Sorex palustris* complex exhibit longitudinally distributed lineages that reflect a Mississippi discontinuity, rapid speciation, high genetic complexity in the west, and ongoing gene flow among species (Hope et al., 2012, 2014a). Similarities in diversification processes are also found among other sciurids. Chipmunks (multiple genera; Patterson and Norris, 2015) have a deeper history of speciation than red squirrels and provide a model for examining how gene flow has impacted the formation of species (Good et al., 2008; Sullivan et al., 2014). In addition, both intra- and inter-specific distributional histories among chipmunks reflect low diversity in eastern North America (*Tamias striatus* and a single lineage of *Neotamias minimus*), as opposed to 22 species that have arisen in western regions (Hall, 1981) with extensive hybridization at range boundaries. Marmots (Genus *Marmota*) also exhibit inter-specific gene flow (Kerhoulas et al., 2015) and the history of diversification of multiple genera of ground squirrels has been accompanied by periodic episodes of introgressive hybridization (Helgen et al., 2009). Recent speciation, coupled with replicated episodes of gene flow, both spatially and temporally, among North American red squirrels should provide novel perspectives on the formation of Nearctic species (Abbott et al., 2013).

4.1. Systematic relationships

Given the extensive range of red squirrels, a comprehensive assessment of systematic relationships and evolutionary history within *Tamiasciurus* has been hampered by limited geographic sampling and associated multi-locus genetic perspectives. Hall (1981) identified substantial morphological variation, recognizing 4 subspecies within *T. douglasii* and 25 subspecies within *T. hudsonicus*. Subsequently, Lindsay (1981) raised *T. d. mearnsi* to species status based on distinctive morphospace among the three species, but lacking range-wide sampling. The first geographically widespread genetic assessment based on a single locus (Arbogast et al., 2001) found no genetic divergence between *T. douglasii* and *T. mearnsi* and instead recovered three independent lineages as western (combined *T. douglasii* and *T. mearnsi*), eastern (all *T. hudsonicus* except for Southwestern populations) and Southwestern (Arizona, New Mexico, and southern Colorado populations of *T. hudsonicus*). Additional mtDNA sequence data identified a paraphyletic relationship of *T. hudsonicus* with respect to *T. douglasii* (including *T. mearnsi*) and reported a distinct lineage located in the Alexander Archipelago of Southeast Alaska (Barber, 2007). Most recently, multiple nuclear loci suggest refugial isolation on Vancouver Island (Chavez et al., 2014), and indicate a complex history of diversification including gene flow, as has been found elsewhere between *T. hudsonicus* and *T. douglasii* (Chavez et al., 2011).

Considering differentiation across multiple loci, climatic niche divergence, and previous morphological evidence, the taxonomy of red squirrels should be updated. The isolated population occurring in Baja California (previously *T. mearnsii*) is minimally divergent from the remainder of the Western lineage over all loci examined; however, a combined western clade representing the Douglas squirrel (*T. douglasii* and *T. mearnsii*) forms one of three species that are well supported over all analyses. The other two species are the southwestern red squirrel (*T. fremonti*; including Southern Rockies, Sacramento Mountains, and Southwestern Sky Island lineages), and the broadly distributed American red squirrel (*T. hudsonicus*) that includes five mtDNA lineages (Continental, Northwestern, Central Rockies, North Pacific Coast, and Vancouver Island). These three species better reflect the evolutionary history and ecology of boreal forest obligates and should improve management and conservation planning.

Although our methods allow for more rigorous representation of systematic relationships within *Tamiasciurus*, the revised taxonomy does not fully account for either incomplete lineage sorting or recent and historic admixture. In this regard, a closer appraisal of the nuclear evidence compared with matrilineal inheritance is informative (Fahey et al., 2014; Hung et al., 2012). Three mtDNA lineages are highly supported as unique among red squirrels, including Vancouver Island, Central Rockies, and NPC lineages; however, all exhibit strong evidence of introgression across different temporal scales. Vancouver Island has fixed mito-nuclear discord where the mitochondria are indicative of *T. douglasii*, but only three haplotypes among nuclear loci examined are private

(most being shared with *T. hudsonicus*). Given the single mtDNA lineage present on Vancouver Island, we concur with Chavez et al. (2014) that this population represents a refugial lineage that persisted through at least part of the last glacial, resulting from a small founder event by hybrid individuals of *T. douglasii*/*T. hudsonicus*. North Pacific Coast and Central Rockies mtDNA lineages are more difficult to interpret. Both exhibit geographically restricted and private nuclear haplotypes, but also share haplotypes with other populations, particularly within *T. hudsonicus* and the Vancouver Island lineage.

4.2. Niche variability among species

Consistent with updated systematic relationships, modeled distributions are indicative of ecological differences among all three species. However, we detected two areas of geographic overlap coincident with regions of hybridization. Overlaps are likely the product of incomplete ecological divergence that includes a narrow set of environmental conditions. For example, although all three species have overall discordant niches ($D = 0.35–0.49$), they all appear to respond similarly to winter precipitation (either the most important or second most important variable), where each is predicted in areas with between 200 and 1000 mm of winter precipitation. Therefore, incomplete ecological differences are likely because of a combination of winter precipitation, temperature evenness, and seasonal variation in temperature and/or precipitation, at distributional peripheries. As a result, in the Rocky Mountains, temperature seasonality differs less between *T. hudsonicus* and *T. fremonti*, allowing these genetically and ecologically divergent species to overlap in peripheral areas. Similarly, in the Pacific Northwest, isothermality (temperature evenness) is most consistent where *T. douglasii* and *T. hudsonicus* meet, allowing them to occupy peripheral areas. There are likely also temporal differences in spatial overlap. For example, the current overlap in the Rocky Mountains may have formed only recently, whereas repeated episodes of isolation and reconnection in Northwestern North America likely permitted greater gene flow in this area.

4.3. Ecology and conservation of regional forest ecosystems

Isolated forest-associated species often reflect classic dynamics of land-bridge island biogeography (Brown, 1971; Patterson, 1982). Because of their age, size, and isolation (e.g., Frey et al., 2007) genetic diversity and effective population size (both at present and historically) likely dictate risk of extirpation due to warming and drying climatic trends compounded with stochastic events (e.g., fire – Koprowski et al., 2005). Conservation of forest peripheral isolates is critical considering that many populations among forest-dwelling species: (1) occur in small, contracting patches of habitat (Holocene refugia), (2) contribute disproportionately to overall genetic diversity, and (3) often exhibit unique adaptations due to their occurrence at the edge of a species' range (Channell and Lomolino, 2000; Hampe and Petit, 2005; Koprowski, 2005).

A clearer understanding of the historical biogeography and systematics of these squirrels enables us to better assess conservation implications for peripheral isolates, due to comprehensive geographic sampling and integrated eco-evolutionary methods (Hope et al., 2013). Peripheral isolates experience high risk of extirpation for several reasons. Small population sizes lead to reduced genetic diversity, although differential selection may contribute to increased rates of divergence and potentially local adaptation (Losos and Ricklefs, 2009). Isolates are also at increased risk of stochastic events coupled with marginal ecological conditions, as has been exemplified by the Mt. Graham red squirrels in southern Arizona (Koprowski et al., 2005) and human-mediated habitat fragmentation. Finally, if isolation persists for extended periods, then subsequent admixture or genetic "rescue" from other populations may dilute recently evolved adaptations, and erode or swamp unique diversity through introgression (Tallmon et al., 2004).

Several populations within North American red squirrel species are under increased threat of extinction due to peripheral isolation. Within *T. douglasii*, the Baja California populations (*T. d. mearnsi*) typify a peripheral isolate, occurring in marginal pine/fir forest habitat through a narrow altitudinal range, with low population density, diagnosable morphological features, and unique haplotypes (De Grammont and Cuarón, 2008). In addition, these populations exhibit unique behavioral and ecological adaptation that are not seen further north (e.g., Koprowski et al., 2006). Furthermore, due to the effects of warming and drying climate trends, continued habitat fragmentation (e.g., wildfire, logging, grazing), and competition from introduced eastern gray squirrels, this southernmost refugial population should be closely monitored (De Grammont and Cuarón, 2008).

Within *T. hudsonicus*, multiple peripheral isolates exist. The hybrid population distributed on Vancouver Island and multiple satellite islands (Fig. 3) is distinct from others along the NPC, indicating the role of multiple isolated refugia in the Pacific Northwest during the last glacial phase. The NPC lineage has an extensive distribution through Southeast Alaska and coastal British Columbia, with six island populations appearing to represent a pure NPC mitochondrial lineage, and three islands where multiple mitochondrial lineages occur. More comprehensive sampling of the vast Pacific coastal archipelagos is needed to clarify the spatial extent of coastal lineages (Fig. 3). Nuclear loci provide a more complex interpretation that may reflect recent or past hybridization or incomplete lineage sorting. The NPC harbors endemic diversity over multiple plant and animal taxa reflecting a long and repeated history of colonization interspersed with isolation on islands due to raised sea levels during interglacials, and isolation in refugia due to ice sheet barriers during glacial phases (Cook et al., 2001). For example, mammals such as ermine (Dawson et al., 2014), wolves (Weckworth et al., 2010, 2015) and marten (Small et al., 2003) show similar patterns of differentiation in this coastal region, likely reflecting prolonged isolation from continental populations. Considering multiple human-mediated introductions of squirrels to individual islands in Southeast Alaska (MacDonald and Cook, 1996), and other human impacts such as old growth timber harvest, squirrels endemic to particular islands may be at high risk. A clearer understanding of the geographic extent of the NPC lineage is imperative, including the dynamics and history of population admixture between discrete lineages. Multiple island populations through this region should provide a lucrative system for investigating hybrid dynamics and processes of local adaptation using genomic methods.

Tamiasciurus fremonti is also represented by multiple insular populations. Of high conservation concern, the Mt. Graham population of *T. fremonti* in the Pinaleño Mountains of Arizona is here assessed for the first time as part of a range-wide genetic evaluation of the species in context with its sister species. We confirm that this population is genetically distinct across loci, but most similar to populations from the Kaibab Plateau in northern Arizona and the Gila region of western New Mexico. In addition to the Pinaleño Mountains, squirrels of the San Mateo Range in central New Mexico appear to be genetically divergent, but our sampling is limited to a single individual. Perhaps most surprisingly, squirrels from the Sacramento Mountains in south-central New Mexico constitute a highly divergent lineage within *T. fremonti*, dated to roughly the last interglacial period (130 ka) and coincident with initial diversification among all lineages within the Southwest. Little evidence of demographic expansion among any lineages of *T. fremonti*, and distinct diversity coincident with isolated mountain ranges indicates a potentially extinction driven system in the

future, if lack of connectivity is coupled with further degradation of montane forested habitats. Limited current gene flow between populations indicates that this species is of high conservation concern. Within the Sacramento Mountains, isolation may be exacerbated by their "high and dry" nature. Red squirrels in the Southwest are restricted to higher elevation conifer forests although they readily utilize blue spruce (*Picea pungens*) corridors along riparian systems. During the last glacial phase, spruce likely extended more widely along riparian corridors, facilitating connections between higher elevation forested areas through the Southwestern Sky Island Archipelago. However, no major riparian corridors now exist between the Sacramento Mountains and other sky islands. Niche predictions support relative isolation of this region through multiple timeframes (Fig. S5).

A significant contribution of a multi-locus and integrated niche-prediction approach to conservation phylogenetics is that, in addition to considering unique peripheral diversity, we can evaluate evolutionary potential within more complex regions where multiple zones of contact exist between sibling species through time (Sullivan et al., 2014). Our niche models predict two broad regions of overlap between the three species of red squirrels, centered over the Southern Rockies and the Pacific Northwest/Interior Highlands ecosystems. Nuclear loci suggest ongoing gene flow. However, considering multiple divergent matrilineages, these regions of contact are likely representative of recent (Holocene) admixture, with hybridization an ongoing dynamic process as climate and environments continue to shift (Hamilton and Miller, 2016; Taylor et al., 2015). Considering that hybridization may either be detrimental to parental species or promote both adaptive potential and diversification (Brennan et al., 2015), these regions of complex contemporary interactions between species, in addition to peripheral populations, constitute critical areas for future research, and conservation-based management.

4.4. Refugia and important ancestral areas of occupation

This multi-locus assessment provides valuable insight for the temporal and spatial development of continent-wide ecological and genetic diversity. Because genetic coalescent estimates and demographics coupled with lineage-specific BEMs can highlight regional responses (Hope et al., 2015), red squirrels provide a basis for identifying common processes shaping the biogeography of forest communities. From niche predictions through time for *T. hudsonicus* (Fig. S7) and multiple distinct matrilineages, we infer several ancestral areas of allopatry during the last glacial phase, generally coincident with those discussed broadly for other taxa (e.g., Swenson and Howard, 2005). Unique nuclear diversity within mitogroups, although minimal, is consistent with these predictions. Major areas were centered upon the eastern and western U.S. south of continental ice sheets and within Beringia, the former two being corroborated by fossil evidence (Kurtén and Anderson, 1980). The Beringian refugium (specifically considering the Northwestern matrilineage of *T. hudsonicus*) was previously hypothesized (Chavez et al., 2014). Our expanded genetic sampling indicates very low historic population size and recent rapid demographic expansion within this lineage (Fig. S3), but with high relative genetic diversity at highest latitudes. Coupled with the current pervasive distribution through Southeast Alaska (not considering human reintroductions), the evidence suggests an early bout of colonization through this region, and likely southward expansion out of Beringia. There is growing evidence for persistence of conifer trees within Beringia through the last glacial phase (Anderson et al., 2006; Brubaker et al., 2005; Zazula et al., 2006), a strict requirement for persistence of these squirrels. In addition, red squirrels are currently widespread in Alaska, occurring within the northernmost conifers south of Anaktuvuk Pass at 68°N (Rausch, 1951).

The NPC lineage of *T. hudsonicus* exhibits relatively high nucleotide diversity and a broad distribution through this extensive archipelago, indicating persistence in one or more coastal refugia. *Tamiasciurus hudsonicus* joins a growing list of taxa for which evidence of refugial persistence exists, and reflecting long-term intact communities along the NPC (Cook and MacDonald, 2013). The mixed distribution of haplotypes coupled with niche predictions within both *T. douglasii*, and independently within mainland populations of *T. hudsonicus* suggests connectivity across much of their current range is recent and glacial phase ranges were more fragmented, particularly through western areas, supporting the concept of "refugia within refugia" (Shafer et al., 2010). The pattern is reversed in *T. fremonti*, in that the fragmented archipelago of sky-island populations represent current refugia considering many of these populations experienced much greater connectivity during the last glacial. However, niche predictions indicate effectively persistent isolation among the three major matrilineages of this species (Fig. S5 – LGM). The Sacramento Mountains were most isolated, while the Southern Rockies were partially isolated from sites further south due to alpine glaciers in southwestern Colorado, a significant set of barriers also hypothesized for other taxa (Barber, 2007).

5. Conclusions

Comprehensive molecular phylogenetic and ecological niche assessment of a widespread genus through North American forest ecosystems provides new insights on speciation across the Nearctic by highlighting how species diverge in response to long-term environmental variability. The obligate association of red squirrels with forests, coupled with relatively recent differentiation accompanied by gene flow, provides perspective on evolutionary responses to climate trends across broadly co-distributed taxa. Specifically within North America, southern peripheral populations of forest species may reflect long-term persistence through glacial cycling in cores habitat areas that is coupled with periodic elevational shifts. In other populations across the continent-wide range, periodic expansion or retraction to predictable refugial areas occur through latitudinal (and longitudinal) shifts as climate changes. In addition to focusing on the management of isolated and potentially shrinking peripheral populations, as contemporary environmental perturbations accelerate, it is critical that we also conserve highly dynamic regions of phylogeographic complexity within forested systems where evolutionary processes associated with gene exchange are influencing biodiversity in ways that are as yet much less clear.

Acknowledgements

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red squirrel specimen records on VertNet at the time of access for use in niche predictions.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ympev.2016.04.014.

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TAXPAYERS for COMMON SENSE

TIMBER REPORT

October 2019

Cutting Our Losses: 20 Years of Money-Losing Timber Sales in the Tongass

Clearcut timber harvest in the Tongass National Forest on Prince of Wales Island, AK. Photo used with permission.

The U.S. Forest Service (USFS) within the Department of Agriculture manages 193 million acres of public forests and grasslands collectively known as the National Forest System. The Tongass National Forest (Tongass) in southeast Alaska is the largest national forest at 16.8 million acres, roughly the size of West Virginia. Every year, the USFS prepares and conducts sales for the rights to harvest millions of board feet of timber from the Tongass. These sales have historically generated less revenue than the USFS spends to administer them, resulting in large net losses for U.S. taxpayers. New budget data reveal that the USFS has continued to lose millions of dollars on Tongass timber sales in recent years.

- **In total, the USFS has lost approximately $600 million over the last twenty years or $30 million per year on average.**
- **USFS could end up losing more than $180 million in the Tongass over the next four years.**

USFS Timber Sales—Background

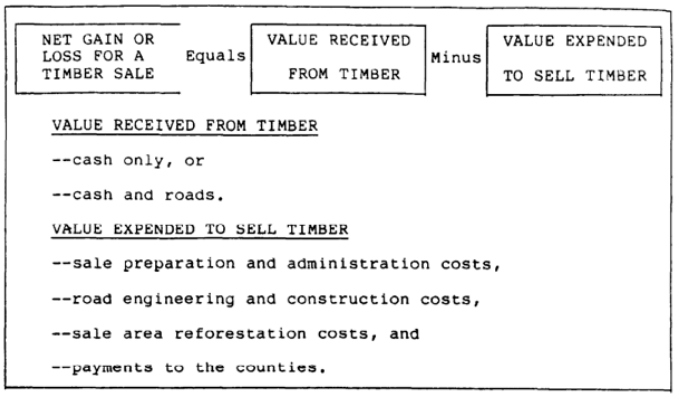
Commercial logging accounts for the vast majority of timber harvest in the Tongass National Forest. To provide for commercial logging consistent with the Tongass Land Management Plan, the USFS prepares and administers commercial timber sales through a complicated process known as the "**Gate System**." As part of this process, the USFS spends years selecting suitable timber stands, thinning them when necessary, analyzing the environmental effects of various harvest options, calculating the sale's financial efficiency, advertising the sale, and evaluating bids from private logging companies. For some sales, the USFS also pays to construct or reconstruct roads to facilitate harvest of the chosen timber stands.

After a successful sale, the winning logging company will harvest the timber and transport it to a sawmill, or when allowed, prepare it

for export. When the value of the cut timber is determined at the sawmill, the logging company pays the USFS the set amount per board foot based on the determined value agreed to during the timber sale. The USFS deposits these receipts and then manages the reforestation and recovery of the affected areas in the Tongass.

Sizing Up Tongass Timber Sales

Whether a timber sale generates a net gain or loss to taxpayers depends on the how much the USFS spent to prepare and administer it, and the amount of revenue collected when the timber is harvested. For decades, the USFS has conducted timber sales in the Tongass that consistently generate huge losses for taxpayers. Various independent analyses have attempted to quantify these losses, but no such evaluation has been conducted in recent years. Newly released budget data indicate that the USFS continues to lose millions of dollars every year on Tongass timber sales.



Source: Government Accountability Office **RCED-84-96**

Net Losses

Over the last 20 fiscal years (FY1999-2018), the USFS spent $632 million in connection with its timber sale program in the Tongass and collected $33.8 million in timber sale receipts, resulting in a net loss of **$598.2 million**, in 2018 dollars. That is, the USFS lost $29.9 million per year, on average from FY1999 to FY2018. Or put another way, Tongass timber sale revenues covered just 5.4 percent of timber sale costs. (See table "Tongass Timber Program: Receipts, Expenses, Losses (FY1999-2018)" for detail.)

Timber sale expenses and revenues fluctuate significantly from one year to the next. A comparison of the three-year moving averages of timber sale losses indicates that losses have decreased substantially over the 20-year period. The inflation-adjusted average loss for FY16-18 of $17.9 million is less than half the average for FY99-01, $38.2 million. Rather than some gain in efficiency, the decrease in losses reflects the lower volume of timber being sold in recent years.

The rate of losses per amount of timber sold has not decreased. During the 20-year period from FY 1999 to 2018, the USFS **reported selling** 977 million board feet of timber in the Tongass. Overall, the USFS lost approximately $612 for every thousand board feet (mbf) of timber it sold. Further, the three-year moving average for losses per mbf more than doubled within the last decade, indicating that the financial efficiency of Tongass timber sales has declined in recent years.

Under **current plans**, the USFS will offer more than 290 million board feet in several timber sales in the Tongass over the next four years. If spending to prepare those sales and the revenue generated from them match the long-run average, the USFS could end up losing more than $180 million.

Receipts Analysis

The USFS reports its "**All Service Receipts**" by national forest, region, and fiscal year to provide transparency into the distribution of receipts to states and localities directed by Congress. Total revenue generated by the USFS timber program includes receipts from commercial timber sales, salvage sales, and amounts deposited into certain trust funds.

Over 20 fiscal years (1999-2018), the USFS has collected a total of $33.8 million from timber sales in the Tongass, after adjusting for inflation. On average, the USFS collected $1.7 million per year in that period, though over the last ten years, the average has dropped to $1.2 million per year.

The timber sales receipts included in the above total are deposited and reported in three separate accounts: National Forest Fund, Knutson-Vandenberg Fund, and Salvage Sales Fund. In short, the Knutson-Vandenberg Fund receives a percentage of timber receipts and uses them to fund timber sale area improvement (reforestation) and some regional cooperative work. The Salvage Sales Fund receives the receipts from sales of

Tongass trees. Source: Joseph, via Flickr Creative Commons

"salvage" timber—timber that is dead, damaged, downed by other natural means, or otherwise in need of clearing—and uses its funds to prepare and administer future salvage sales.

Outlays Analysis

Over the 20 fiscal years (1999-2018), the USFS spent $632 million, adjusted for inflation, in association with timber sales in the Tongass. On average, the USFS spent $31.6 million per year, but annual expenses have declined steadily over the two decades. In that period, the inflation-adjusted, three-year moving average of Tongass timber expenses dropped by more than half from $45.1 million to $18.6 million.

Of the $632 million, $334 million was spent from the "Forest Products" account, the primary fund for preparing and administering timber sales. For road construction and maintenance, the USFS spent $221 million. Expenditures from the Knutson-Vandenberg Fund, Salvage Sales Fund, and Reforestation Trust Fund make up the remaining $38 million.

Methodology Note — The USFS does not report how much it spends to prepare and administer timber sales individually or collectively. As a result, estimates of USFS timber sale losses often vary due to different determinations of which expenses are appropriately categorized as timber sale outlays.

In this analysis, outlays associated with timber sales represent the total of six budget line items. These six budget accounts fund three types of USFS activity: timber sale preparation, reforestation, and road building. The latter is included because the vast majority of roads in the Tongass have been built and maintained to facilitate timber harvest.[1] Other expenses that are necessary for timber sales but primarily serve other Forest Service missions, such as forest inventory and monitoring activities, were not included.

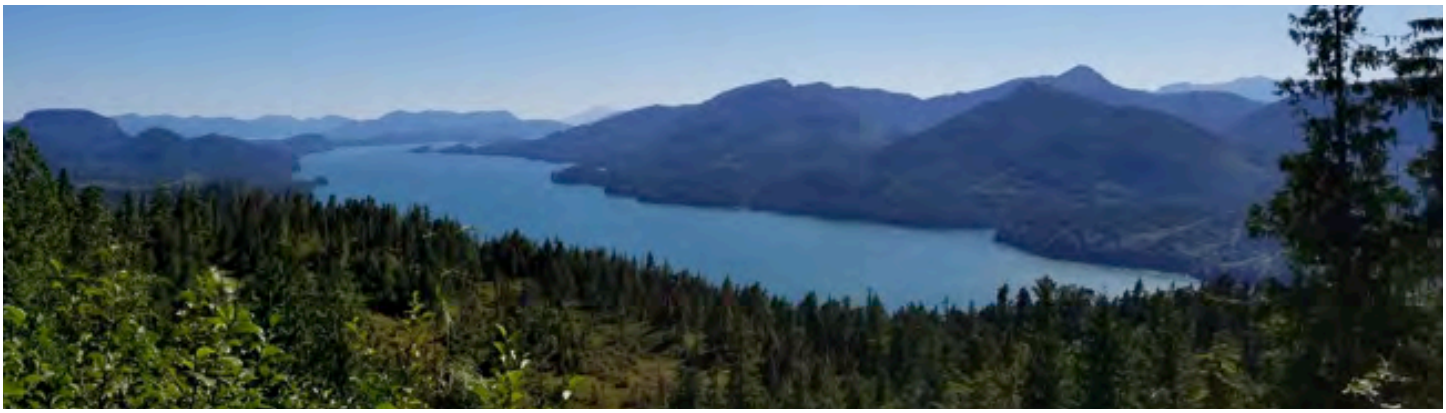
Information on USFS budget allocations and expenses in the Tongass is generally unavailable to the public. The USFS provided Tongass budget data to Taxpayers for Common Sense in response to several formal and informal information requests dating back to 2004.

Comparison and Discussion

The USFS' administration of timber sales throughout the National Forest System, and in the Tongass specifically, has been scrutinized for decades. The Government Accountability Office (GAO), an independent congressional watchdog, has published dozens of reports assessing various aspects of the USFS timber program including harvest levels, contract bidding, road construction, cost accounting systems, receipt distribution, reforestation, data deficiencies, and below-cost sales, among others.

In one of its first reports on the economics of USFS timber sales in 1984, the GAO found that 27 percent of sales in fiscal year (FY) 1981 and 42 percent of sales in FY 1982 were below-cost.[2] After increased Congressional scrutiny in the 1980s, GAO helped the USFS design a new accounting system to address severe deficiencies in the agency's collection and reporting of timber sale data—the Timber Sale Program Information Reporting System (TSPIRS).[3]

[1] U.S. Forest Service, *Tongass National Forest—Land and Resource Management Plan Amendment*. Final Environmental Impact Statement, Vol. II—Appendix C, Table C-1.
[2] U.S. General Accounting Office (now, Government Accountability Office) - GAO. RCED-84-96, "Congress Needs Better Information on Forest Service's Below-Cost Timber Sales." June 28, 1984. **https://www.gao.gov/products/RCED-84-96**
[3] U.S. GAO. AFMD-87-33, "TIMBER PROGRAM: A Cost Accounting System Design for Timber Sales in National Forests." April 21, 1987. **https://www.gao.gov/products/AFMD-87-33**



Carroll Inlet in the Tongass National Forest. Source: Wikimedia Commons

In 1988, the GAO reported that USFS timber sales had lost $22.1 million in FY1986,[4] roughly equivalent to $50.6 million in 2018 dollars. As its most recent estimate, the GAO reported in 2016 that Tongass timber sales had lost $11.4 million per year on average during the period FY2005-2014. The agency was careful to note, however, that its estimate excluded USFS roadbuilding costs.[5]

Like the GAO calculations in previous reports, this analysis represents a basic accounting of the Tongass timber program on a *cash* basis—reflecting what outlays are paid and receipts are collected in a given year. The profitability of a specific timber sale is more appropriately measured on an *accrual* basis—where the amounts spent to prepare and administer a timber sale over many years are matched against the receipts collected when the sold timber is eventually harvested. However, the USFS does not publicly release its financial data for each timber sale, making such analysis impossible.

Conducting a cash-flow analysis of the timber program instead can have significant limitations. Comparing the receipts collected from previous timber sales and spending for future sales in any one year can provide a skewed indication of timber sale profitability. Over a longer period, however, discrepancies between when expenses and receipts are tallied diminish, and a cash-basis accounting more accurately estimates the overall financial return from timber sales. By looking at timber receipts and program expenses over 20 years, the approach adopted in this report not only mirrors most previous attempts to quantify Tongass timber losses, but also provides a more accurate assessment of overall timber sale performance.

Lastly, given current efforts to exempt the Tongass National Forest from the 2001 National Roadless Area Conservation Rule ("Roadless Rule"),[6] roadbuilding costs will likely increase. The USFS constructs or reconditions roads to provide harvesters access to timber stands it sells. Covering roadbuilding costs improves the economics of a timber sale for logging companies, but also significantly increases the total costs of the USFS timber program. In fact, USFS spending on roads in the Tongass made up more than 40 percent of all timber sale expenses from FY1999 to FY2018.

The 2001 Roadless Rule prohibits new road construction and reconstruction in inventoried roadless areas with national forests, including 9.2 million acres in the Tongass. Exempting those acres from the rule in the future would allow the USFS to expand timber sales to new areas, which would require comparatively more road construction for timber access. This would only drive up USFS expenses and deepen taxpayer losses from Tongass timber sales.

[4] U.S. GAO. RCED-88-54, "TONGASS NATIONAL FOREST: Timber Provision of the Alaska Lands Act Needs Clarification." April 11, 1988. **https://www.gao.gov/products/RCED-88-54**

[5] U.S. GAO. GAO-16-456, "TONGASS NATIONAL FOREST: Forest Service's Actions Related to Its Planned Timber Program Transition." April 25, 2016. **https://www.gao.gov/products/GAO-16-456**
By excluding roadbuilding costs in its 2016 estimate, the GAO significantly understated the losses associated with Tongass timber sales.

[6] See TCS Comments to the USFS during the Roadless Rule Scoping Period. Available at: **https://www.taxpayer.net/energy-natural-resources/tcs-submits-comments-to-the-us-forest-service-on-its-roadless-rule-scoping/**

Tongass Timber Program: Receipts, Expenses, Losses (FY1999-2018)

($ in millions)

FISCAL YEAR	TIMBER VOLUME SOLD (MBF)	TIMBER RECEIPTS	TIMBER EXPENSES	NET RECEIPTS	TIMBER RECEIPTS: ($2018)	TIMBER EXPENSES ($2018)	NET RECEIPTS ($2018)
2018	9,211	$0.4	$18.1	**-$17.7**	$0.42	$19.07	**-$17.65**
2017	20,808	$1.0	$17.8	**-$16.7**	$1.04	$18.20	**-$17.16**
2016	13,535	$0.5	$18.5	**-$18.1**	$0.47	$19.40	**-$18.92**
2015	22,625	$0.3	$19.7	**-$19.5**	$0.29	$20.91	**-$20.62**
2014	105,523	$0.6	$22.4	**-$21.8**	$0.6	$23.8	**-$23.1**
2013	15,866	$0.6	$19.7	**-$19.1**	$0.6	$21.2	**-$20.6**
2012	52,483	$1.9	$21.5	**-$19.6**	$2.0	$23.5	**-$21.5**
2011	44,190	$3.3	$18.0	**-$14.8**	$3.7	$20.1	**-$16.5**
2010	45,632	$1.9	$22.3	**-$20.4**	$2.2	$25.7	**-$23.5**
2009	22,670	$0.6	$26.4	**-$25.7**	$0.7	$30.8	**-$30.1**
2008	5,351	$0.4	$23.5	**-$23.1**	$0.5	$27.4	**-$27.0**
2007	30,392	$0.3	$25.1	**-$24.8**	$0.3	$30.4	**-$30.1**
2006	85,007	$0.8	$27.9	**-$27.1**	$1.0	$34.8	**-$33.8**
2005	65,075	$0.4	$34.4	**-$34.0**	$0.5	$44.2	**-$43.7**
2004	87,072	**-$4.3**	$36.9	**-$41.2**	**-$5.7**	$49.1	**-$54.8**
2003	36,489	$2.0	$31.0	**-$29.0**	$2.7	$42.3	**-$39.6**
2002	24,372	$1.3	$33.4	**-$32.2**	$1.8	$46.7	**-$44.9**
2001	49,592	$1.8	$35.0	**-$33.2**	$2.6	$49.6	**-$47.1**
2000	170,329	$6.9	$23.8	**-$16.9**	$10.0	$34.7	**-$24.7**
1999	61,426	$5.3	$33.8	**-$28.5**	$8.0	$51.0	**-$42.9**
2009-2018 TOTAL	**362,544**	**$11.0**	**$204.4**	**-$193.4**	**$12.1**	**$221.8**	**-$209.7**
1999-2018 TOTAL	**977,649**	**$25.9**	**$509.4**	**-$483.5**	**$33.8**	**$632.0**	**-$598.2**

Tongass National Forest
Timber Sale Program
Adaptive Management Strategy

December 2016

LEGEND

- Phase 1
- Phase 2
- Phase 3
- Non-Development LUD
- State of Alaska ROW (PL 109-59) and Final Southeast Alaska Transportation Plan (2004)
- Alaska Marine Highway and Inter-Island Ferry Authority
- VCU Boundary
- Water
- Non-Federal Land
- Glacier Bay National Park
- Haines State Forest
- Klondike Gold Rush National Historic Park
- BLM-managed Land

Russia
Arctic Ocean
Bering Sea
Alaska
Canada
Gulf of Alaska
Tongass National Forest
0 250 500 1,000 Miles

Topographic Relief of the Tongass National Forest

0 5 10 20 30 40 50 Miles

Yukon Territory
British Columbia
CANADA
UNITED STATES
GULF OF ALASKA
DIXON ENTRANCE

Glacier Bay National Park (Wilderness)
RUSSELL FIORD
YAKUTAT BAY
YAKUTAT
YAKUTAT FORELANDS
KLUKWAN
SKAGWAY
HAINES
ENDICOTT RIVER
LYNN CANAL
GUSTAVUS
ELFIN COVE
PELICAN
HOONAH
JUNEAU
DOUGLAS
ADMIRALTY ISLAND NATIONAL MONUMENT
TENAKEE SPRINGS
KADASHAN
CHATHAM STRAIT
STEPHENS PASSAGE
KOOTZNOOWOO WILDERNESS
TRACY ARM-FORDS TERROR
ANGOON
SITKA
SOUTH BARANOF
FREDERICK SOUND
KAKE
PETERSBURG
STIKINE
LECONTE
PORT ALEXANDER
KUIU
WRANGELL
COFFMAN COVE
HOMEPAGE
SOUTH ETOLIN
ANAN CREEK
CLARENCE STRAIT
MAURELLE ISLANDS
THORNE BAY
MEYERS CHUCK
KLAWOCK
CRAIG
KARTA RIVER
HOLLIS
OUTSIDE ISLANDS
MISTY FIORDS NATIONAL MONUMENT WILDERNESS
HYDER
NAHA
HYDABURG
KETCHIKAN
SAXMAN
NUTKWA
METLAKATLA
MISTY FIORDS NATIONAL MONUMENT
SOUTH PRINCE OF WALES

United States Department of Agriculture
Forest Service

Alaska Region

Tongass National Forest
Ketchikan, Alaska

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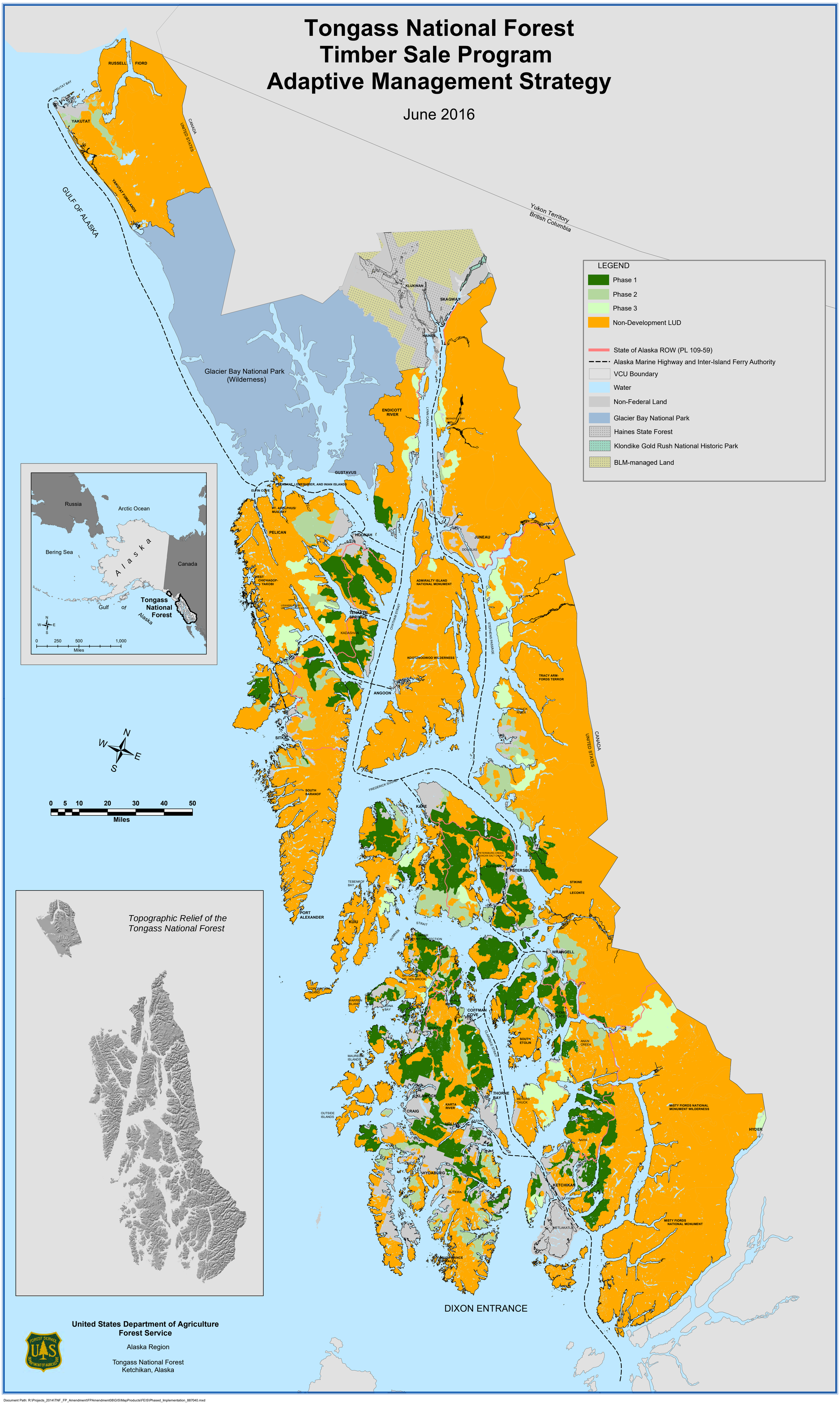
Tongass National Forest
Timber Sale Program
Adaptive Management Strategy

June 2016



United States Department of Agriculture
Forest Service

Alaska Region

Tongass National Forest
Ketchikan, Alaska

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United States Department of Agriculture

Tongass Land and Resource Management Plan

Final Environmental Impact Statement

Plan Amendment

SUMMARY

Forest Service
Alaska Region

Tongass National Forest

R10-MB-769h

June 2016

Tongass National Forest

Welcome

This Summary accompanies a Final Environmental Impact Statement (EIS) and Land and Resource Management Plan (Forest Plan), which have been prepared to document the analysis of alternatives for the 2016 Tongass Forest Plan Amendment. A Draft Record of Decision (ROD) is also included. Most planning participants will be receiving an electronic version of these documents on a CD. The CD contains a cover letter, Draft ROD, Final EIS (two volumes), Forest Plan, and supporting maps. The Final EIS is available as a complete

We recommend you start your review by reading the cover letter.

Tongass Forest Plan Amendment documents are also available on the Forest Plan amendment website: http://www.fs.usda.gov/goto/R10/Tongass/PlanAmend. News, information, updates, notices, and other documents related to the forest plan amendment can be found in the plan amendment newsroom: http://www.fs.usda.gov/detailfull/tongass/landmanagement/?cid=stelprd3828076&width=full.

The website includes a variety of products developed in support of this project, and easy access to other associated Web sites.

The draft decision to amend the Tongass Forest Plan is subject to the

approving the plan amendment, there will be an objection process per Forest Service regulations at 36 CFR 219, subpart B; published April 9, 2012 (77 FR 21162) that applies to plan amendments. This proposed plan amendment is subject to 36 CFR 219, subpart B. All documents (Draft Record of Decision, Final EIS, and Forest Plan) will be made available online at the time of public notice for

36 CFR 219.53, who have submitted substantive formal comments related to the plan amendment during the opportunities for public comment as provided in subpart A (reference 36 CFR 219.16), may

The objection period and required 30-day timeframe for reviewing the Final EIS will run concurrently
process for the amended Tongass Forest Plan will be published in the Federal Register and newspapers of record (*Juneau Empire* and *Ketchikan Daily News*). All notices will be published on the Tongass Plan Amendment website: http://www.fs.usda.gov/goto/R10/Tongass/PlanAmend. Those who have subscribed to receive amended Tongass

How to Use the CD

The CD-ROM has an "autostart" feature that should start the application when you put the CD in your computer. If the application starts correctly, a Welcome page containing links to the documents should open up. If the CD does not start by itself shortly after you insert it in your CD drive, then

Introduction

Forest land and resource management planning is a process for developing, amending, and revising land and resource management plans for each of the National Forests in the National Forest System (NFS). Forest plans are required by the National Forest Management Act of 1976 (NFMA) (16 United States Code [U.S.C.] parts 1600-1687). The 16.7-million-acre T
forest to complete a Land and Resource Management Plan (Forest Plan) under the NFMA in 1979. That Forest Plan was amended in 1986 and 1991 and revised in 1997. A
Environmental Impact Statement (SEIS) was completed in 2003, which further evaluated roadless areas for their wilderness potential. The Forest Plan was amended again in 2008 in response to a Ninth Circuit Court ruling and a 5-Year Plan Review completed in 2005. The revised Plan was amended 24 times between the 1997 revision and the 2008 amendment, primarily to adjust small old-growth habitat reserve boundaries and for electronic/communication site designations. Since the 2008 amendment, the plan has been amended to establish the Héen Latinee Experimental Forest, disestablish the Young Bay Experimental Forest, add communication sites to the list in Appendix E, modify small old-growth habitat reserves, and make minor corrections to the plan.

On July 2, 2013, Secretary of Agriculture, Thomas Vilsack, issued Memorandum 1044-009, *Addressing Sustainable Forestry in Southeast Alaska* (U.S. Department of Agriculture [USDA] 2013), which expressed the Secretary's intent to transition the Tongass National Forest to a young growth–based timber program in 10 to 15 years, more rapidly than considered in the 2008 Forest Plan. The Secretary asked that the Forest Service "[s]trongly consider whether to pursue an amendment to the Tongass Forest Plan. Such an amendment would evaluate which lands will be available for timber harvest, especially young growth timber stands, which lands should be excluded, and additional opportunities to promote and speed transition to young-growth management." Recognizing the importance of retaining expertise and infrastructure, the Secretary also stated that the Forest Service "will continue to offer a supply of old growth timber while increasing the supply of young growth to provide industry in Alaska

the opportunity to develop new markets, learn new skills, and acquire new equipment." The Secretary also asked that a determination of whether to initiate an amendment be completed by September 30, 2013.

The Forest Service completed a Five-Year Review of the Forest Plan in September 2013. The results of the Five-Year Review and the Secretary's Memorandum led to the Tongass Forest Supervisor making a determination that "…conditions on the land and demands of the public require the Tongass to modify the 2008 Forest Plan" (USDA Forest Service 2013a). A Notice of Intent (NOI) to prepare an EIS was published in the Federal Register on May 27, 2014 (79 Federal Register [FR] 30074) initiating a 30-day scoping period. Among the comments from the Five-Year Review and from scoping were those that requested a transition to young-growth timber harvesting, ways to make renewable energy projects easier to implement, and a review of the 2001 Roadless Area Conservation Rule (Roadless Rule) inventoried roadless areas (IRAs). All comments were taken into consideration in identifying the scope of this Forest Plan amendment.

This Final Environmental Impact Statement (FEIS) is a programmatic analysis prepared by the Forest Service that describes and analyzes changes to the Forest Plan to accomplish the transition to young-growth management as provided in the Secretary's Memorandum. This FEIS evaluates which lands will be suitable for timber production, especially young-growth timber stands, and any changes or additions to management direction needed to promote and speed the transition to young-growth management while maintaining a viable timber industry in Southeast Alaska. This FEIS also describes and analyzes changes related to renewable energy development. The scope of the analysis is limited to these changes.

This FEIS analyzes in detail four action alternatives for amending the Plan, in addition to a No Action Alternative (Alternative 1). The analysis is published in two volumes. Volume 1 contains the FEIS, and Volume 2 contains the FEIS appendices. A complete Forest Plan Land Use Designation (LUD) map is provided for each of the alternatives in the Map Packet which accompanies the FEIS.

A separate document titled Tongass Land and Resource Management Plan (i.e., the Forest Plan) is published along with the FEIS and represents the selected alternative (Alternative 5). Chapter 2 and Appendix F in the FEIS describe how the other alternatives compare to Alternative 5. Instead of repeating all of the changes in management direction common to Alternatives 1-4 and Alternative 5, management direction of the alternatives is displayed in a side-by-side comparative format to demonstrate how and where direction differs from Alternative 5.

This FEIS describes and analyzes changes to the 2008 Forest Plan and tiers to and incorporates by reference the 1997 Tongass Land Management Plan Revision FEIS (1997 FEIS), the 2003 Final Supplemental EIS (SEIS) for Roadless Area Evaluation for Wilderness Recommendations (2003 FSEIS), and the 2008 Tongass Land and Resource Management Plan Amendment FEIS (2008 FEIS), and the 2008 Record of Decision (2008 ROD). Where appropriate, information in these documents that is relevant to analysis in this FEIS is cited and incorporated by reference.

Purpose and Need

The Forest Service determined that it is necessary to amend the 2008 Forest Plan. Amending the Forest Plan originates from the July 2013 memo from the Secretary of Agriculture directing the Tongass National Forest to transition its forest management program to be more ecologically, socially, and economically sustainable, while also being responsive to comments from the Five-Year Review of the Forest Plan. The purpose of this plan amendment is to:

- Review lands within the plan area to determine suitability for timber production, especially young-growth timber stands.
- Identify the projected timber sale quantity (PTSQ) and the sustained yield limit (i.e., the ecological yield of timber that can be removed annually on a sustained yield basis).
- Establish plan components (e.g., standards and guidelines)

for young-growth forest management and renewable energy development to guide future project decision-making.

- approval.

An amendment is necessary for responding to the July 2013 direction from USDA Secretary Tom Vilsack outlined in the Secretary's Memorandum 1044-009. The memorandum directs management of the Tongass National Forest to expedite the transition away from old-growth timber harvesting and towards a forest products industry that uses predominantly second-growth – or young-growth – forests. Secretary Vilsack's memorandum also directs that the transition must be implemented in a manner that preserves a viable timber industry that provides jobs and opportunities for Southeast Alaska residents. USDA's goal is to effectuate this transition, over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth. This timeframe will conserve old-growth forests while allowing the forest industry time to adapt. The 2008 Forest Plan provides for a transition to young growth over time, but there are challenges in establishing an economically viable young-growth forest management program due to the relatively young age of the available stands, market conditions, and other factors. Secretary Vilsack's direction requires Forest Plan amendments to guide future management of NFS lands and allocation of resources on the Tongass National Forest under the multiple-use and sustained yield mandate.

The need to amend the plan is further corroborated by the Five-Year Review of the Forest Plan, completed in 2013, which concluded that conditions on the land and demands of the public necessitate the Tongass National Forest to make changes to the Forest Plan. Concerns were consistently expressed during the Five-Year Review regarding the impact of rising fossil fuel prices and increasing climate change on the quality of life in Southeast Alaska. Changes to the Forest Plan are needed to make the development of renewable energy resources more permissible, including considering access and utility corridors to stimulate economic development in

Southeast Alaska communities, and provide low-carbon energy alternatives, thereby displacing the use of fossil fuel.

The Forest Service used the scoping process to determine the scope

a proposed action.

scoping.

Issue 1 – Young Growth Transition

The Secretary of Agriculture asked the Forest Service to transition to a young-growth-based timber management program on the Tongass National Forest in 10 to 15 years, which is more rapid than planned. This transition is intended to support the Tongass managing its forest for an ecologically, socially, and economically sustainable forest management program and reduce old-growth harvest while still providing economic timber to support the local forest products industry.

, salability, and volume of future timber sales. It also relates to the potential local employment and revenues generated for communities in the local area. Young-growth stand growth rates, sustainable harvest rates, the amount of old-growth harvest needed during transition to sustain the timber industry, also known as "bridge timber," and the locations where young-growth harvest would take place are some of the factors to be considered.

Issue 2 – Renewable Energy

The development of renewable energy projects on the Tongass would help Southeast Alaska communities reduce fossil fuel dependence, stimulate economic development, and lower carbon emissions in the Region.

This issue relates to comments received during the Five-Year Review of the Forest Plan. The Forest Service should promote the

development of renewable energy projects to help Southeast Alaska communities reduce fossil energy dependence, where it is compatible with National Forest purposes and to ensure that the planning, construction, and operation of projects protect and effectively use NFS lands and resources.

Issue 3 – Inventoried Roadless Areas

Timber harvest and road building that occurred in roadless areas before the 2001 Roadless Area Conservation Rule (Roadless Rule) was enacted and during the Tongass exemption period changed the values or features that often characterize inventoried roadless areas in some locations.

Issues and concerns received during scoping as well as during the Five-Year Review process expressed concerns about roadless areas on the Tongass; both in favor of protections afforded under the 2001 Roadless Rule as well as requesting that the forest plan be amended

on the Tongass.

Some people believe roadless areas on the Tongass should be allowed to evolve naturally through their own dynamic processes and should be afforded protection that ensures this will occur. Others believe that limiting road construction and reconstruction or other management actions in roadless areas might restrict the delivery of goods, services, and activities that these areas might otherwise provide.

Roadless areas are considered important because they support a diversity of aquatic and terrestrial habitats, species, and communities, and play an important role in helping to conserve native plant and animal communities and biological diversity. They also provide people with unique recreation opportunities.

During the Tongass exemption period and before the 2001 Roadless Rule was enacted, road construction, reconstruction, and the cutting, and sale of timber in some IRAs occurred. As a result, these activities in some IRAs may have altered the roadless characteristics.

Issue 4 – Wildlife Habitat and the Conservation Strategy

Old-growth timber harvest has changed the composition and spatial patterns of terrestrial wildlife habitats. How the resulting young-

of the landscape at various scales. Changes made to suitable lands designated for development, and to plan components (e.g., standards and guidelines) may affect old-growth habitat for wildlife and the Tongass Old-growth Habitat Conservation Strategy and contributing elements to old-growth reserves (e.g., riparian, beach and estuary habitats).

The Tongass National Forest supports an important assemblage of wildlife many of which are associated with or at least partially dependent on old-growth forest including one of the largest populations of brown bears in the world, high densities of breeding bald eagles, the Alexander Archipelago wolf, species of high importance for subsistence (e.g., Sitka black-tailed deer), an extensive array of endemic mammals, and other species that are dependent on old-growth habitats (e.g., marten and goshawk). The Tongass Old-growth Habitat Conservation Strategy is considered important for the continued health of old-growth associated wildlife populations in Southeast Alaska.

Timber harvest, minerals and renewable energy development, and road development can have effects on the habitat and populations of many of these species and the diversity and integrity of Southeast Alaska ecosystems. Less than 10 percent of the productive old-growth habitat on the Tongass has been converted to young growth, the percentage is much higher for certain types of old growth, such as lowland and large-tree old growth. In addition, non-NFS old growth has generally been harvested at a much higher rate. Therefore, the consideration of harvest and road building on wildlife in Southeast Alaska are greater than the effects for the Tongass by itself.

Alternatives

Forest Plan

The current 2008 Forest Plan is associated with the No Action Alternative (Alternative 1). However, a number of changes to the Forest

Plan text are being proposed. These changes are incorporated into a Forest Plan (Land and Resource Management Plan), which accompanies the EIS. The Forest Plan was developed based on the Preferred Alternative (Alternative 5).The individual alternative descriptions on the following pages identify the major changes in the Forest Plan.

Timber Demand

In past Forest Plan revisions and amendments, varying demand scenarios were used to develop alternatives, including scenarios that allowed for growth and expansion of the current industry. In this

transition away from old-growth timber harvesting and towards a forest products industry that uses predominantly second-growth – or young-growth – forests. Therefore, examination of alternatives at levels above projected demand is not warranted because these would require expansion of old-growth harvest levels, at least during the next 10 to 15 years. However, over the longer term, expansion of the timber industry is an option as more and more young growth becomes economic to harvest.

Therefore, Alternatives 1 through 5 were designed to correspond with current demand projections and produce a projected timber sale quantity (PTSQ)[1] of about 46 MMBF per year during the next 15 years, with old growth making up a decreasing percentage of the total. Old-growth volume would continue to decrease until it reaches about 5 MMBF per year and it would remain at that level, to support limited small timber operators. As more young growth becomes economic to harvest, the PTSQ would be allowed to increase. In no case, would the harvest level be allowed to exceed the sustained yield limit (SYL) (see Glossary and the *Timber* section of this EIS).

Even though Alternative 1 (no action) represents current management, it is modeled to follow the same volume production pattern. The July 2013 Secretary'
direction in the 2008 Forest Plan (see Purpose and Need in Chapter 1) and without this amendment, the Tongass would be transitioning toward young-growth and away from old-growth harvest.

[1] The term allowable sale quantity (ASQ) is not used with the 2012 planning rule.

Provisions Common to all Alternatives

ung-growth stands may be harvested. Under Public Law 113-291, up to 15,000 acres of young growth may be harvested from 2016 through 2025, in stands less than 95 percent of CMAI.
2025 (with annual maximums); however, the total acreage harvested at less than 95 percent of CMAI cannot exceed 50,000. In addition, young-growth sales under this provision may not be offered unless they [2] to allow a continuation of harvesting at younger ages beyond 2025.

LUD Changes Common to the Action Alternatives

The LUD allocations for each alternative are described in the following The LUDs for Alternative 1 (no action) are the same as the LUDs of the current Forest Plan. The LUDs of the action alternatives are different from Alternative 1 LUDs because of Old-growth Habitat LUD changes. Under Public Law 113-291, approximately 70,000 acres of NFS land were conveyed to Sealaska Corporation and an additional 152,000 acres were converted to LUD II. As a result of the land conveyance, old-growth reserves (OGRs) in 16 VCUs were affected. Beginning in February 2015, an interagency review team of biologists worked to develop a biologically preferred option for modifying these OGRs that meets Forest Plan Appendix K criteria and to document why other proposals are not recommended. In September 2015, the interagency review team produced a biologically preferred option (see Appendix E), which was incorporated into each of the action alternatives. Therefore, the Old-growth Habitat LUD acres vary between Alternative 1 and the action alternatives (Alternatives 2, 3, 4, and 5).

In addition, the Transportation and Utility Systems LUD would be removed under Alternatives 2, 3, 4, and 5. The LUD management prescription would be replaced by plan components under Alternatives 2, 3, 4, and 5 and would provide management direction

[2] Any sale of trees pursuant to the authority granted under subparagraph (A) shall

when appraised using a residual value appraisal.

for renewable energy and transportation systems corridors (see Chapter 5 in the proposed Forest Plan).

Alternative 1 (No Action)

The No Action Alternative represents current management direction (2008 Forest Plan) and includes the application of the Roadless Area Conservation Rule (2001 Roadless Rule) (36 CFR 294 Subpart B). As noted above, it also follows the direction provided in the July 2013 Secretary'
from old-growth harvest. Under this alternative, timber harvest would follow the existing timber sale program adaptive management strategy (USDA Forest Service 2008c). A color map showing the phases in this strategy is provided along with the FEIS. Timber harvest is currently restricted to areas within Phase 1 of the strategy and timber harvest would have to reach 100 MMBF for two years before harvest could occur in Phase 2 areas. Timber management would be restricted to the development LUDs and would remain outside of inventoried roadless areas. No commercial harvest would be allowed in beach and estuary fringe or RMAs. All other 2008 Forest Plan management direction would be followed.

As noted previously, due to Public Law 113-291, CMAI requirements for determining the youngest age for harvest would be eliminated on up to 50,000 acres of young-growth. However, beyond that, the minimum harvest age would return to 95 percent of CMAI except under exemptions provided by the NFMA.

Alternative 1 would result in the most old-growth harvest among the alternatives over both 25-year and 100-year periods. Table 2-2 summarizes the key elements of Alternative 1 and Table 2-3 summarizes the LUD acres, mapped suitable acres, and projected harvest acres under this alternative for young growth and old growth.

This alternative would harvest timber at a rate of 46 MMBF per year (equivalent to the harvest needed to meet the projected timber demand, see Table 2-1). It would emphasize young growth and minimize old growth while maintaining 46 MMBF per year. As such, it is expected to produce about 8 MMBF of young growth and 38 MMBF of old
Year 10
through Year 25, it is projected to produce about 15 MMBF of young

growth and 31 MMBF of old growth per year. At about Year 32, the young-growth harvest is expected to increase to about 41 MMBF and the old-growth harvest would decrease to 5 MMBF per year. The young-growth harvest is expected to continue to increase at a rapid rate after Year 32 and is expected to reach an upper limit of about 133 MMBF in about Year 38. The old-growth harvest rate would be held at 5 MMBF per year to support small and micro sales.

Key Elements of Alternative 1

Old-growth Harvest

- Follows 2008 Forest Plan Timber Sale Program Adaptive Management Strategy for Phases 1, 2, and 3
- No harvest allowed in Inventoried Roadless Areas

Young-growth Harvest

- Allows harvest in Development LUDs, including Clearcutting
- Allows no harvest in Natural Setting LUDs
- Allows no harvest in Inventoried Roadless Areas
- Allows no commercial harvest in Beach and Estuary Fringe or in RMAs
- There is to harvest 50,000 acres at a younger age than 95 percent of CMAI per Public Law 113-291
- Scenery standards (SIOs) would not be for young growth

LUD Changes

- None

Other New Plan Components (Chapter 5)

- None

Alternative 2 (Proposed Action)

As in Alternative 1, this alternative would follow the existing timber sale program adaptive management strategy for old-growth harvest (USDA Forest Service 2008c) (see color map accompanying the FEIS); as a result, all old-growth harvest would come from Phase 1, After harvest volume exceeds 100 MMBF for two years, it is possible that limited old-growth harvest could occur in Phase 2 areas. Young-growth harvest could

come from any phase of the strategy at any time. The portions of inventoried roadless areas (IRAs) that were roaded before the 2001 Roadless Rule and during the 2001 Roadless Rule exemption period for the Tongass would be available for young-growth and old-growth harvest. This would require rulemaking to modify 36 CFR 294.13(b)(4). If selected, no harvest could occur in IRAs until rulemaking is completed. No Roadless Area harvest outside of these roaded areas would be allowed.

Alternative 2 would differ substantially from Alternative 1 in terms

Young-growth management would be allowed in both development and natural setting LUDs (except for Congressionally designated and administratively withdrawn areas, such as Wilderness, and islands less than 1,000 acres in size), in beach and estuary fringe, RMAs outside of Tongass Timber Reform Act (TTRA) buffers, and high-vulnerability karst.

Young-growth management may include clearcutting in all areas, except in RMAs and on high-vulnerability karst, where only commercial thinning (up to 33 percent basal area removal) would be allowed. After 15 years, clearcutting would no longer be allowed in the beach and estuary fringe and only commercial thinning would be allowed. In addition, in beach and estuary fringe, the intent is to maintain an approximate 1,000-foot wide protected corridor adjacent and inland of any even-aged harvest unit to function as an alternate, low elevation, natural habitat corridor.

Scenery standards for young-growth management would be relaxed. The SIOs would be designated as Very Low for all LUDs and distance zones.

As noted previously, due to Public Law 113-291, CMAI requirements for determining the youngest age for harvest would be eliminated on up to 50,000 acres of young-growth. Beyond that, the minimum

by NFMA.

The Forest Plan would include new management direction that

gy development under this

alternative. Scenery standards for renewable energy development would be relaxed to Very Low for all LUDs and distance zones.

Among the action alternatives, Alternative 2 would provide the largest amount of timber volume (old growth and young growth combined), including the largest amount of young-growth volume from lands suitable for timber production. It would result in the smallest amount of old growth timber volume over both 25-year and 100-year periods. Table 2-5 summarizes the key elements of Alternative 2 and Table 2-6 summarizes the LUD acres, mapped suitable acres, and projected harvest acres under this alternative for young growth and old growth.

This alternative would harvest timber at a rate of 46 MMBF per year (equivalent to the harvest needed to meet the projected timber demand, see Table 2-1), emphasizing young growth and minimizing old growth. As such, it is expected to produce an average of about 22 MMBF of young growth and 24 MMBF of old growth per year Years 11 through 15, Alternative 2 is projected to produce an average of 61 MMBF of young growth and 5 MMBF of old growth per year. Alternative 2 would likely reach a full transition harvest of 41 MMBF of young growth about Year 12. Young-growth harvest is expected to continue to increase at a rapid rate after Year 12 and is expected to reach an upper limit of about 120 MMBF in Year 17. The old-growth harvest rate would be held at 5 MMBF per year to support small and micro sales.

Key Elements of Alternative 2

Old-growth Harvest

- Allows harvest only within Phase 1 of the 2008 Timber Sale Program Adaptive Management Strategy.
- The portions of IRAs that were previously roaded would be available for harvest after rulemaking.

Young-growth Harvest

- Allows harvest in Development LUDs, including clearcutting, and entry into all phases of the Timber Sale Program Adaptive Management Strategy without regard to harvest volumes.
- Allows harvest in natural setting LUDs, except for Congressionally designated and administratively withdrawn areas and islands smaller than 1,000 acres.
- The portions of IRAs that were previously roaded would be available for harvest after rulemaking.
- Commercial harvest is allowed in beach and estuary fringe, in high-vulnerability karst, and in RMAs outside of TTRA buffers (details below).
- Clearcutting is allowed on all lands suitable for timber production (including natural setting LUDs), except RMAs and high-vulnerability karst where only commercial thinning is allowed. The maximum removal in RMAs outside of TTRA buffers is 33 percent (basal area). Clearcutting in beach and estuary fringe is not allowed after 15 years.
- In beach and estuary fringe, the intent is to maintain an approximate 1,000-foot wide protected corridor adjacent and inland of any even-aged harvest unit.
- There is to harvest at a younger age than 95 percent of CMAI throughout the life of the Plan.
- Scenery standards would be relaxed to Very Low SIO for young-growth harvest.

LUD Changes

- Old Growth Habitat LUDs are to correspond with the biologically preferred option in areas where they were adversely affected by land conveyances and other changes resulting from Public Law 113-291.
- The Transportation and Utility Systems LUD is removed.

New Plan Direction (Forest Plan Chapter 5)

- Young-growth plan components added to Forest Plan.
- Renewable Energy plan components added to Forest Plan (including relaxation of SIO to Very Low for renewable energy development).
- Transportation Systems Corridors plan components added to Forest Plan.
- Forest-wide plan direction added to Forest Plan.

Alternative 3

Alternative 3 would allow old-growth harvest only in Phase 1 of the existing timber sale program adaptive management strategy (USDA Forest Service 2008c) (see color map accompanying this FEIS) but would allow young-growth harvest in all phases. This alternative would allow young-growth and old-growth harvest in 2001 Roadless Rule IRAs. If this alternative were selected, harvest in IRAs would

(2001).

Alternative 3 is similar to
suitable for young-growth timber production in both development and natural setting LUDs (except for Congressionally designated areas such as Wilderness, administratively withdrawn areas, and islands less than 1,000 acres in size), as well as in beach and estuary fringe and high-vulnerability karst, but not in RMAs. Young-growth management may include clearcutting in all areas, except in beach and estuary fringe and on high-vulnerability karst, where only commercial thinning is allowed.

In addition, for young-growth harvest units larger than 20 acres in VCUs that have had concentrated past timber harvest, it is intended that 30 percent of the young growth stand acres should be left. This legacy provision would be described as a Management Approach in the Forest Plan.

Scenery standards for young growth management would be reduced by one level relative to the 2008 Forest Plan. SIOs would be reduced as follows: High would be reduced to Moderate, Moderate would be reduced to Low, and Low and Very Low would become Very Low.

As noted previously, due to Public Law 113-291, CMAI requirements for determining the youngest age for harvest would be eliminated on up to 50,000 acres of young growth. Beyond that, the minimum

by NFMA.

The Forest Plan would include new management direction that
gy development under this alternative. The SIO (scenery standard) for renewable energy development would Low for all LUDs and distance zones.

Summary

Alternative 3 would provide the second largest amount of timber volume (old growth and young growth combined). It would result in the second lowest harvest of old growth over both the 25-year and 100-year periods. Table 2-8 summarizes the key elements of Alternative 3 and Table 2-9 summarizes the LUD acres, mapped suitable acres, and projected harvest acres under this alternative for young growth and old growth.

This alternative would harvest timber at a rate of 46 MMBF per year (equivalent to the harvest needed to meet the projected timber demand, see Table 2-1). It would emphasize young growth and minimize old growth while maintaining 46 MMBF per year. As such, it is expected to produce an average of about 20 MMBF of

10 years (Figure 2-5). From Year 11 through Year 15, it is projected to produce an average of 50 MMBF of young growth and about 5 MMBF of old growth per year. Alternative 3 would likely reach a full transition harvest of 41 MMBF of young growth at about Year 13. Young-growth harvest is expected to continue to increase at a rapid rate after Year 13 and is expected to reach an upper limit of about 117 MMBF in Year 17. The old-growth harvest rate would be held at 5 MMBF per year to support small and micro sales.

Key Elements of Alternative 3

Old-growth Harvest

- Allows harvest only within Phase 1 of the 2008 Timber Sale Program Adaptive
- Management Strategy.
- Inventoried Roadless Areas (IRAs) would be available for harvest after rulemaking.

Young-growth Harvest

- Allows harvest in Development LUDs, including clearcutting, and entry into all phases of the Timber Sale Program Adaptive Management Strategy without regard to harvest volumes.
- Allows harvest in natural setting LUDs, except for congressionally designated and administratively withdrawn areas and islands smaller than 1,000 acres.
- IRAs would be available for harvest after rulemaking.
- Commercial harvest is allowed in beach and estuary fringe but not in RMAs.
- Clearcutting is allowed in all areas except beach and estuary fringe and high- vulnerability karst, where only Commercial Thinning is allowed.
- Management Approach to provide legacy in young-growth harvest units larger than 20 acres in certain VCUs.
- There is to harvest at a younger age than 95 percent of CMAI throughout the life of the Plan.
- Scenery standards for young growth management would be relaxed; SIOs would be reduced by one level relative to the 2008 Forest Plan (i.e., High is reduced to Moderate, Moderate is reduced to Low, and Low and Very Low become Very Low).

LUD Changes

- Old-growth Habitat LUDs are to correspond with the biologically preferred option in areas where they were adversely affected by land conveyances and other changes resulting from Public Law 113-291.
- The Transportation and Utility Systems LUD is removed.

New Plan Direction (Forest Plan Chapter 5)

- Young-growth plan components added to Forest Plan.
- Renewable Energy plan components added to Forest.
- Transportation Systems Corridors plan components added to Forest Plan.
- Forest-wide plan direction added to Forest Plan.

Alternative 4

Like Alternative 3, this alternative would allow old-growth harvest only in Phase 1 of the existing timber sale program adaptive management strategy (see color map accompanying this FEIS), but in contrast with Alternative 3, it would also limit young-growth harvest to only Phase 1. Similar to Alternative 1, this alternative includes the application of the 2001 Roadless Rule.

Alternative 4 would allow young-growth management only in the development LUDs. Harvest is allowed in beach and estuary fringe and on high-vulnerability karst, but only commercial thinning is allowed. No harvest is allowed in RMAs. Young growth management may include clearcutting in other areas.

In addition, for young-growth harvest units larger than 20 acres in VCUs that have had concentrated past timber harvest, it is intended that 30 percent of the young growth stand acres should be left. This legacy provision would be described as a Management Approach in the Forest Plan.

No change would occur in scenery standards relative to the 2008 Forest Plan.

As noted previously, due to Public Law 113-291, CMAI requirements for determining the youngest age for harvest would be eliminated on up to 50,000 acres of young-growth. Beyond that, the minimum

by NFMA.

The Forest Plan would include new management direction that

gy development under this alternative. The SIO (scenery standard) for renewable energy development would Low for all LUDs and distance zones.

Alternative 4 would provide the smallest amount of timber volume (old growth and young growth combined) and the smallest amounts of young-growth volume. It would result in the second highest harvest of old growth during both the 25-year and 100-year periods. Table 2-11 summarizes the key elements of Alternative 4, and Table 2-12 summarizes the LUD acres, mapped suitable acres, and

projected harvest acres under this alternative for young growth and old growth.

This alternative would harvest timber at a rate of 46 MMBF per year (equivalent to the harvest needed to meet the projected timber demand, see Table 2-1). It would emphasize young growth and minimize old growth while maintaining 46 MMBF per year. As such, it is expected to produce an average of about 11 MMBF of

10 years (Figure 2-7). From Year 11 through Year 15, it is projected to produce an average of 26 MMBF of young growth and about 20 MMBF of old growth per year. Alternative 4 would likely reach a full transition harvest of 41 MMBF of young growth about Year 16. Young-growth harvest is expected to continue to increase at a rapid rate after Year 16 and is expected to reach an upper limit of 87 MMBF about Year 18. The old-growth harvest rate would be held at 5 MMBF per year to support small and micro sales.

Key Elements of Alternative 4

Old-growth Harvest

- Allows harvest only within Phase 1 of the 2008 Timber Sale Program Adaptive Management Strategy.
- No harvest is allowed in IRAs.

Young-growth Harvest

- Allows harvest in development LUDs, including clearcutting, but allows entry only in Phase 1 of the Timber Sale Program Adaptive Management Strategy.
- Allows no harvest in natural setting LUDs.
- Allows no harvest in IRAs.
- Commercial harvest is allowed in beach and estuary fringe and in high-vulnerability karst within development LUDs, but no harvest is allowed in RMAs.
- Clearcutting is not allowed in beach and estuary fringe and high-vulnerability karst; only commercial thinning is allowed.
- Management Approach to provide legacy in young-growth harvest units larger than 20 acres in certain VCUs.
- There is to harvest before 95 percent of CMAI throughout the life of the Plan.
- No changes would occur in scenery standards relative to the 2008 Forest Plan.

LUD Changes

- Old-Growth Habitat LUDs are to correspond with the biologically preferred option in areas where they were adversely affected by land conveyances and other changes resulting from Public Law 113-291.
- The Transportation and Utility Systems LUD is removed.

New Plan Direction (Forest Plan Chapter 5)

- Young-growth plan components added to Forest Plan.
- Renewable Energy plan components added to Forest Plan.
- Transportation Systems Corridors plan components added to Forest Plan.
- Forest-wide plan direction added to Forest Plan.

Alternative 5 (Preferred Alternative)

Alternative 5 is the Preferred Alternative. This alternative is based on the recommendations from the Tongass Advisory Committee (TAC), a formally established Federal Advisory Committee (see Appendix B of the Forest Plan). The establishment of the TAC represents a turning point in Tongass management seeking new approaches, practices, and responses. The TAC offers a regionally focused, collaborative path toward an innovative opportunity for a viable young growth timber industry while honoring the suite of values – economic, ecological, social, and cultural – inherent in the Forest.

Like Alternatives 3 and 4, this alternative would allow old-growth harvest only within Phase 1 of the timber sale program adaptive management strategy (see color map accompanying this FEIS). As in Alternatives 1 and 4, the 2001 Roadless Rule would apply and no old-growth or young-growth harvest would occur in roadless areas. In addition, old-growth harvest is excluded from all Tongass 77 (T77)[3] watersheds and TNC/Audubon Conservation Priority Areas (Albert and Schoen 2007). These old-growth harvest exclusion areas are shown on the large color map for Alternative 5 that accompanies this FEIS.

As in Alternatives 2, 3, and 4, Alternative 5 would allow young-growth harvest in all three phases of the timber sale program adaptive management strategy. It would allow young-growth management in development LUDs and in the Old-growth Habitat LUD including harvest in beach and estuary fringe and RMAs outside of TTRA buffers within these same LUDs. However, young-growth harvest in the Old-growth Habitat LUD, beach and estuary fringe, and RMAs outside of TTRA buf
15 years after Plan approval, and created openings for commercial harvest (up to 10 acres and a maximum removal of up to 35 percent of the acres of the original harvested stand) or commercial thinning would be allowed. In beach and estuary fringe, a 200-

[3] The Tongass 77 (T77) refers to value comparison units (VCUs), which approximate major watersheds located on National Forest System lands that Trout Unlimited, As a result of the Sealaska Land Entitlement Finalization in the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015 (Public Law 113-291), there was a net reduction in the T77 watersheds from 77 to 73. To provide clarity and consistency, the T77 nomenclature will continue to be used in this document when referring to these priority watersheds.

foot no-commercial harvest buffer adjacent to the shoreline would be required. Along lake shorelines, a 100-foot no-cut commercial harvest buffer would be established. Scenery standards (SIOs) for young growth management would be reduced to Very Low for all distance zones in the development LUDs only. This standard would also apply when young-growth and old-growth harvests are planned in the same Viewshed.

As noted previously, due to Public Law 113-291, CMAI requirements for determining the youngest age for harvest would be eliminated on up to 50,000 acres of young-growth. Beyond that, the minimum

by NFMA.

The Forest Plan would include new management direction that

gy development under this alternative. The SIO (scenery standard) for renewable energy development would Low for all LUDs and distance zones.

Alternative 5 would provide the second smallest amount of timber volume (old growth and young growth combined) among the alternatives, but the second largest amount of old-growth volume among the action alternatives. Table 2-14 summarizes the key elements of Alternative 5 and Table 2-15 summarizes the LUD acres, mapped suitable acres, and projected harvest acres under this alternative for young growth and old growth.

This alternative would harvest timber at a rate of 46 MMBF per year (equivalent to the harvest needed to meet the projected timber demand, see Table 2-1). It would emphasize young growth and minimize old growth while maintaining 46 MMBF per year. As such, it is expected to produce an average of about 12 MMBF of

10 years (Figure 2-9). From Year 11 through Year 15, it is projected to produce an average of 28 MMBF of young growth and about 18 MMBF of old growth per year. Alternative 5 would likely reach a full transition harvest of 41 MMBF of young growth about Year 16. Young-growth harvest is expected to continue to increase at a rapid rate after Year 16 and is expected to reach an upper limit of 98 MMBF about Year 18. The old-growth harvest rate would be held at 5 MMBF per year to support small and micro sales.

Key Elements of Alternative 5

Old-growth Harvest

- Allows harvest only within Phase 1 of the 2008 Timber Sale Program Adaptive Management Strategy.
- No harvest is allowed in IRAs.
- No harvest is allowed within the T77 watersheds or the TNC/ Audubon conservation priority watersheds.

Young-growth Harvest

- Allows harvest in Development LUDs, including clearcutting, and entry into all phases of the Timber Sale Program Adaptive Management Strategy without regard to harvest levels.
- Allows harvest in Old Growth Habitat LUDs, but not in other natural setting LUDs or on islands less than 1,000 acres
- No harvest is allowed in IRAs.
- Commercial harvest is allowed in beach and estuary fringe outside of a 200-foot buffer and in RMAs outside of TTRA buffers.
- A 100-foot no-cut buffer is established around all lakes.
- In Old Growth Habitat LUDs, Beach Fringe (outside of the 200-foot buffer) and in RMAs outside of TTRA buffers, clearcutting is not allowed, but patch cuts (≤10- acre openings and a maximum of 35 percent removal) is allowed, along with commercial thinning. Harvest is allowed in these land categories only during the 15 years after plan approval.
- There is to harvest at a younger age than 95 percent of CMAI throughout the life of the Plan.
- The scenery standards (SIOs) would be reduced to Very Low in development LUDs only.

LUD Changes

- Old Growth Habitat LUDs are to correspond with the biologically preferred option in areas where they were negatively affected by land conveyances and other changes resulting from Public Law 113-291.
- The Transportation and Utility Systems LUD is removed.

New Plan Direction (Chapter 5)

- Young-growth plan components added to Forest Plan.
- Renewable Energy plan components added to Forest Plan.
- Transportation Systems Corridors plan components added to Forest Plan.
- Forest-wide plan direction added to Forest Plan.

Comparison of the Alternatives

in Chapter 1. This comparison is based on the effects analyses presented in Chapter 3.

Issue 1 – Young-growth Transition

The purpose and need for this project is primarily based on a memorandum from the Secretary of Agriculture (see Chapter 1) that directs management of the Tongass National Forest to expedite the transition away from old-growth timber harvesting and towards a forest products industry that utilizes predominantly second-growth – or young-growth – forests. Secretary Vilsack's memorandum also guides that the transition should be implemented in a manner that preserves a viable timber industry that provides jobs and opportunities for Southeast Alaska residents. USDA's goal is to effectuate this transition, over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth. This timeframe will conserve old growth forests while allowing the forest industry time to adapt.

Because of the Secretary's memorandum, the existing condition emphasizes a transition to young growth and minimizes old-growth harvest, but does this within the constraints of the 2008 Forest Plan. Alternative 1 (no action) would result in full transition to a predominantly young-growth-based industry in about 32 years, well beyond the 15 year goal presented in the Secretary's memorandum. In contrast, all of the action alternatives would result in a full transition in about 12 to 16 years. Because these timeframes represent full transition, the period in which the "vast majority of timber sold by the Tongass will be young growth" is expected to be about 10 to 15 years for the action alternatives. Of the action alternatives, the fastest transition (12 years) would occur with Alternative 2 and the slowest transition (16 years) would occur with Alternatives 4 and 5.

All of the alternatives are expected to support from 184 to 231

portion of total harvest that is exported. Total estimated jobs are very similar across the alternatives, with the highest number of direct jobs supported by Alternative 2 and the lowest number of direct jobs supported by Alternative 1. In addition, each alternative is expected to meet the projected demand for Tongass timber. Therefore, each alternative is expected to meet the criterion of maintaining a viable industry. However, it is unclear how quickly industry will be able to "retool" mills and harvesting equipment and how markets will react to changing from old-growth to young-growth forest products; thus, this criterion is associated with a relatively high degree of uncertainty.

Under all alternatives, the harvest of old growth would diminish over time and the harvest of young growth would increase. Therefore, all of the alternatives would "conserve old-growth forests." The largest

with Alternative 1. Each of the action alternatives would harvest less old growth, ranging from 15,000 acres with Alternative 2 to 24,000 acres with Alternative 5. The same pattern among the alternatives occurs with the 100-year harvest as well.

Issue 2 – Renewable Energy

Another important part of the purpose and need for this project is the purpose of establishing new direction in the Forest Plan so that renewable energy development is more permissible. There is a need to stimulate economic development in Southeast Alaska communities, and provide low-carbon energy alternatives, thereby displacing the use of fossil fuel. Under the 2008 Forest Plan, siting of energy projects is limited in certain LUDs, and it would remain that way under Alternative 1. Under each of the action alternatives (Alternatives 2, 3, 4, and 5), changes would be made to

development of renewable energy projects.

Issue 3 – Inventoried Roadless Areas

Under Alternatives 1, 4, and 5 IRAs are withdrawn from timber production and not suitable for timber production (FSH 1909.12,

chapter 60, section 61.11). In Alternative 2, IRAs that were previously roaded would be available for road construction and timber harvest and in Alternative 3, all IRAs would be available for road construction and timber harvest. In both Alternatives 2 and 3, entry into IRAs would not be permitted without rulemaking or, in the case of Alternative 3, if the 2003 Tongass Exemption (68 FR 75136) is reinstated. Estimated acres of timber harvest in IRAs over 100 years would range from 0 acres for Alternatives 1, 4, and 5, to 11,000 acres for Alternative 2, to 29,000 acres for Alternative 3. The protection of roadless characteristics would be directly proportional to the projected acres of timber harvest with Alternatives 1, 4, and 5 providing the most protection, Alternative 2 providing the second most protection, and Alternative 3 providing the least protection.

Issue 4 – Wildlife Habitat and the Conservation Strategy

Relative to old-growth habitat conservation, Alternative 1 would have the highest harvest (1.3 percent of existing POG), followed by Alternative 4 (0.9 percent of existing POG), followed by Alternative 5 (0.8 percent of existing POG), followed by Alternatives 2 and 3 (0.7 percent of existing POG). The change in the percent of original POG remaining after 100 years would follow the same pattern. Currently, 92 percent of original POG is remaining; under all alternatives this percentage would drop by about 1 percent after 100 years. Alternative 1 would result in about 90 percent remaining and the action alternatives would each result in about 91 percent remaining. This same pattern would continue for the percent reduction in high-volume POG. The existing 86 percent of original high-volume POG remaining would be reduced to about 85 percent for all alternatives after 100 years. For large-tree POG, about 79 percent of the original acres exist. Alternative 1 would result in about 78 percent remaining after 100 years, while the action alternatives would maintain about 79 percent.

Young-growth harvest in the beach and estuary fringe would be lowest under Alternative 1 (no harvest). Under the action

alternatives, no harvest of POG would occur, but impacts resulting from young growth harvest would be highest under Alternative 2, which would include the second highest amount of young-growth acres and would allow clearcutting. Under Alternatives 3 and 4, considerable young-growth acreage would be harvested, but using commercial thinning, which would result in less effects than clearcutting. Alternative 5 would have the lowest effect on beach and estuary fringe among the action alternatives because young-growth acreage would be lowest and only patch cutting (with created openings up to 10 acres and a maximum removal of up to 35 percent of the acres of the original harvested stand) or commercial thinning Plan approval with a one-time entry restriction.

For RMAs, the lowest effects would be associated with Alternatives 1, 3, and 4, which would permit no harvest in RMAs. Alternative 2 would have the greatest harvest impacts in RMAs because it would include the highest amount of acreage and would allow clearcutting thinning thereafter. Effects to RMAs would be lower under Alternative 5 due to a lower amount of acres harvested and only patch cutting or commercial thinning would be permitted and only time entry restriction.

In the Old-growth Habitat LUD, Alternatives 1 and 4 would allow no young-growth harvest. The greatest amount of young-growth harvest in the Old-growth Habitat LUD would occur under Alternative 2, followed by Alternatives 3 and 5. Effects would be greatest under Alternative 2 because it would allow clearcutting and have the largest harvest acreage, and less under Alternative 3 because only commercial thinning would be allowed, followed by Alternative 5 which would allow only patch cutting or thinning and only during e entry restriction.

Summary

Average total road density across the Forest (NFS lands only) under all alternatives would be approximately 0.23 mile per square mile after 100 years, an increase of 0.03 to 0.04 mile per square mile above existing levels. Approximately 83 percent of WAAs would have total road densities ranging between 0.0 and 0.7 mile per square mile under all alternatives. Total roads are conservatively

roads. Average open road density across the Forest (NFS lands only) would be approximately 0.09 mile per square mile, an increase of approximately 0.005 mile per square mile under all alternatives. Approximately 96 percent of WAAs would have open road densities ranging between 0.0 and 0.7 mile per square mile under all alternatives. Therefore, any potential increase in hunter access or risk of overharvest for wildlife species would be minor and localized, and would not be measurable at the forest-wide scale under any of the alternatives.

The transition to young-growth management would slow the long-term decrease in deer habitat capability due to the reduction in POG harvest. Based on Interagency Deer Habitat Capability model outputs, deer habitat capability under all of the alternatives would decline about 1 percent over 100 years. Forest-wide all alternatives would maintain about 99 percent of the existing deer habitat capability. Results based on the Forage Resource Evaluation System for Deer (or FRESH deer model) are very similar; Forest-wide, the existing level of habitat quality would be decline about 1 percent after 100 years under all alternatives.

Cumulative POG harvest on all landownerships would be greatest under Alternative 1, followed by Alternatives 4, 5, 3, and 2 (in that order). Cumulative effects would be least under the alternatives that propose the shortest young-growth transition time. After 100 years of Forest Plan implementation and non-NFS harvests, approximately 83 percent of the original (1954) total POG forest, about 76 percent of the original high-volume POG, and 63 to 64 percent of the original large-tree POG would be maintained on all landownerships under all of the alternatives.

Cumulative road densities (all land ownerships) would be similar among alternatives (about 0.45 mile per square mile), representing an increase of about 0.11 to 0.12 miles per square mile above current conditions. Open road densities for all land ownerships would increase from about 0.22 mile per square mile to about 0.24 mile per square mile after 100 years under all alternatives.

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Main Cover Photo: Photograph taken looking northwest from above Neets Bay on north Revillagigedo Island. An unnamed cove and timber harvest on the peninsula lie in the foreground with Gedney Pass and Hassler Island in the background (right).

Inset Photo on Back: Blue Lake Hydroelectric Project (courtesy Desiree Brandis)

United States Department of Agriculture

Tongass Land and Resource Management Plan

Final Environmental Impact Statement

Plan Amendment

Volume II - Appendices

Forest Service
Alaska Region

Tongass National Forest

R10-MB-769f

June 2016

Tongass National Forest
Proposed Land and Resource Management Plan

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APPENDIX A
SCOPING AND COMMENT SUMMARY REPORT

Tongass Forest Plan Amendment Scoping and Comment Summary Report

Tongass National Forest

Prepared by:

Tetra Tech, Inc
19803 North Creek Parkway
Bothell, Washington 98011

August 17, 2015

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ANILCA	Alaska National Interest Lands Conservation Act
ASQ	allowable sale quantity
CMAI	Culmination of Mean Annual Increment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
Forest Plan	Land and Resource Management Plan
Forest Service	U.S. Department of Agriculture, Forest Service
FWS	Fish and Wildlife Service
IRA	inventoried roadless area
LUD	Land Use Designation
MIS	Management Indicator Species
NEPA	National Environmental Policy Act
NFS	National Forest System
NOI	Notice of Intent
OGR	old-growth reserve
SOA	State of Alaska
TUS	Transportation and Utility System
YAC	Youth Advisory Council
YG	young growth

1.0 PROJECT SUMMARY

The U.S. Department of Agriculture, Forest Service (Forest Service) is preparing an Environmental Impact Statement (EIS) that evaluates an amendment to the 2008 Tongass National Forest Land and Resource Management Plan (Forest Plan). The Record of Decision will consider and identify changes, if any, to the current 2008 Forest Plan.

2.0 BACKGROUND

On July 2, 2013, Secretary of Agriculture, Thomas Vilsack, issued Memorandum 1044-009, *Addressing Sustainable Forestry in Southeast Alaska*, which expressed the Secretary's intent to transition the Tongass National Forest (the Tongass or Forest) to a young growth–based timber program in 10 to 15 years, more rapidly than considered in the 2008 Forest Plan. He asked that the Forest Service "strongly consider whether to pursue an amendment to the Tongass Forest Plan. Such an amendment would evaluate which lands will be available for timber harvest, especially young growth timber stands, which lands should be excluded, and additional opportunities to promote and speed transition to young growth management."

In order to achieve the young-growth (YG) transition goal of 10 to 15 years, the initial phase of the National Environmental Policy Act (NEPA) documentation has been initiated. Notice of Intent (NOI) to prepare an Environmental Impact Statement was originally published in the Federal Register on May 27, 2014. On June 23, 2016, a corrected Notice of Intent was published modifying the expected timeline, providing details on the objection process under 36 CFR 219 subpart B, and identifying M. Earl Stewart as the Forest Supervisor.

In addition, the Forest Service completed a 5-year review of the Forest Plan in September 2013. There were a total of 257 unique comment submissions and over 152,000 form letters received during the comment period for the 5-year review. Many of the comments on the 5-year review also requested a transition to young-growth timber harvesting. All of these comments were taken into consideration in identifying the scope of this Forest Plan amendment.

In January and February 2015, open houses were held in Juneau, Sitka, and Ketchikan to share information with the public about the progress being made on the Proposed Forest Plan Amendment and Draft Environmental Impact Statement, and to provide opportunity for the public to comment on the Draft Plan Monitoring Program. An informational newsletter was also published in conjunction with the open houses, providing project information and detailing how the public can participate.

3.0 PURPOSE AND NEED FOR PROJECT

The Purpose and Need for Action, as defined in the Notice of Intent (NOI), is:

> "The Forest Service is preparing an Environmental Impact Statement (EIS) to describe the effects of making proposed changes to the Tongass Forest Plan to accomplish the transition to young growth management as provided in the Secretary's Memorandum. The Forest Service will evaluate which lands should be available for timber harvest, especially young-growth timber stands, and any proposed changes to standards and guidelines and other management direction to promote and speed the transition to young-growth

management while maintaining a viable timber industry in Southeast Alaska. It will also evaluate other changes suggested in the 5-year review."

4.0 PROPOSED ACTION

The Proposed Action, as defined in the Notice of Intent (NOI), is:

> "The Forest Service proposes to amend the Tongass Forest Plan, using the 2012 Planning Rule, as needed to accomplish the transition to young growth management over the next 10 to 15 years while retaining the expertise and infrastructure of a viable timber industry in Southeast Alaska, as outlined by the Secretary in Memorandum 1044-009. The amendment process will address: Identifying areas suitable and not suitable for timber harvest to achieve the transition to young growth management; whether the Tongass needs to be able to harvest young growth forest stands before they reach their maximum rate of growth; what changes in management direction should be made to promote young growth management; whether the inventory of roadless areas should be updated, which may require additional rulemaking; whether changes are needed to provide for development of hydropower; updating the upper limit on the quantity of timber that may be sold from the Tongass to reflect other changes made; and how to modify the monitoring provisions of the Plan as required by the 2012 Planning Rule, including identifying focal species to monitor instead of management indicator species as required by the former planning regulations. The amendment process may address other topics relevant to promoting and speeding the transition to young growth management. It is not expected that changes made to the Tongass Forest Plan will affect the overall integrity of the Plan's conservation strategy."

5.0 OPPORTUNITIES FOR COMMENT AND PARTICIPATION

5.1 FIVE-YEAR REVIEW

The Forest currently operates under the Tongass National Forest Land and Resource Management Forest Plan, as amended in 2008. In 2013, the Forest Service completed a 5-year review to determine whether any actions are needed to clarify or adjust the plan. The Tongass solicited comments through public and stakeholders meetings, government-to-government consultation with Southeast Alaska tribes, and written comments. Press releases, radio announcements, project brochures, postcards, letters posters and email notices were used to notify the public. Additionally, letters of invitation to participate were sent to 32 tribes in 16 communities.

Public comments were accepted between January and June 30, 2013. Public meetings were hosted in February and March 2013 in the communities of Wrangell, Petersburg, Sitka, Craig, Ketchikan, Juneau and Haines. Additionally, Conservation Strategy Summits were hosted in June 2013 in the communities of Ketchikan and Juneau. Then Forest Supervisor Cole received input on a range of topics, including young-growth management, the Roadless Rule, watershed restoration, mining, renewable energy, and local economies. All of the comments received were taken into consideration in identifying the scope of this Forest Plan amendment. A detailed summary of the Five-Year Review process and comment summary is available online at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5443864.pdf (USDA Forest Service 2013)

In October 2013, the Forest Service announced its intent to modify the Forest Plan based on the conditions of the land and the demands of the public. Identification of the timber base suitable to support a transition to young-growth management in a way that supports the continued viability of the forest industry in Southeast Alaska was noted as a focus area.

5.2 SCOPING PROCESS

The NOI initiated the scoping process, which helped guide the development of the EIS. The NOI to prepare an environmental impact statement was published in the Federal Register on May 27, 2014 (79 FR 30074) initiating a 30-day public scoping period. The NOI asked for public comment on the proposal until June 26, 2014. The Forest Service received over 116,000 letters and of these, about 250 letters were unique.

5.3 PUBLIC MEETINGS

In January and February 2015, open houses were held in Juneau, Sitka, and Ketchikan to share information with the public about the progress being made on the Proposed Forest Plan Amendment and Draft Environmental Impact Statement, and to provide opportunity for the public to comment on the Draft Plan Monitoring Program. While comments were not solicited on the Forest Plan Amendment during these meetings, Forest Service staff were on hand and materials were made available to the public to inform them on the amendment process and how and when to provide input. Approximately 15-20 people attended each meeting.

5.4 CONSULTATION WITH FEDERALLY RECOGNIZED TRIBAL GOVERNMENTS AND TRIBAL CORPORATIONS

The Forest Service invited the following tribal governments and corporations to participate as cooperating agencies:

- Angoon Community Association
- Central Council Tlingit & Haida Indian Tribes of Alaska
- Chilkat Indian Village
- Chilkoot Indian Association
- Craig Tribal Association
- Douglas Indian Association
- Hoonah Indian Association
- Hydaburg Cooperative Association
- Organized Village of Kake
- Organized Village of Kasaan
- Ketchikan Indian Community
- Klawock Cooperative Association
- Metlakatla Indian Community
- Petersburg Indian Association
- Organized Village of Saxman
- Sitka Tribe of Alaska
- Skagway Traditional Council
- Wrangell Cooperative Association
- Yakutat Tlingit Tribe

While none of the invited tribal governments or corporations are participating as cooperating agencies, all will be engaged with through consultation.

5.5 CONSULTATION WITH OTHER AGENCIES

The Forest Service invited the Environmental Protection Agency (EPA), Fish and Wildlife Service (FWS), and the State of Alaska (SOA) to participate as cooperating agencies in the development of the EIS. . The FWS accepted this invitation and is participating as a cooperating

agency. The EPA formally declined the invitation. The EPA, FWS, and SOA submitted comments during the scoping comment period.

5.6 TONGASS ADVISORY COMMITTEE

As a result of both the 5-Year Review and the July memorandum from the Secretary of Agriculture, Memorandum 1044-009, a Federal Advisory Committee was established to provide advice on identifying ways to support the transition and provide for a viable forest industry in Southeast Alaska. The Tongass Advisory Committee (TAC) was federally chartered in 2014 to advise the Secretary of Agriculture on developing an ecologically, socially, and economically sustainable forest management strategy for the Tongass National Forest. The TAC was tasked with developing recommendations about how to transition within 10 to 15 years from old-growth to predominantly young-growth timber management in a way that is economically viable for the existing industry, while recognizing and balancing the other unique and equally important resource values of the Tongass. The TAC was comprised of fifteen members from the timber industry, conservation community, Native interests, State and local government, and other interests. The TAC provided recommendations to the Secretary of Agriculture in May 2015 and the Forest Service developed an alternative based on these recommendations to be included in the EIS.

5.7 YOUTH ADVISORY COMITTEE

The 2012 Planning Rule requires the responsible official to provide meaningful opportunities for public participation throughout the planning process. It gives direction for providing such opportunities, including for outreach. In 2014, Tongass National Forest officials reached out to a Ketchikan High School guidance counselor who assembled 8 students to form the Ketchikan High School Youth Advisory Council (YAC). Three YAC meetings were held at Ketchikan High School from fall 2014 through spring 2015. The objective was to involve the YAC members in the public participation process for the proposed Forest Plan Amendment, including having them actively participate in a Forest Service public open house meeting in Ketchikan. This meeting allowed YAC members to better understand the scope of the Forest Plan Amendment and the issues that were raised during the scoping process. They gathered information at each station, examined maps, and talked with Forest Service subject matter experts. In May 2015, several members of the YAC had the opportunity to meet with Forest Service staff and the Tongass Advisory Committee, a Federal Advisory Committee during a social event at Ward Lake Recreation Area where they discussed the importance of collaboration and civic involvement.

For the school year 2015-2016, the YAC is comprised of 11 students, both Juniors and Seniors, who have demonstrated leadership tendencies, have a high grade point average, and are interested in understanding the scope of Forest Planning and how they can participate in the effort. A meeting was held on October 21, 2015 to welcome new YAC members. The goal of the YAC is to formulate consolidated comments on the proposed Forest Plan and associated DEIS during the 90-day comment period.

6.0 ISSUE DEVELOPMENT

The Interdisciplinary Team identified the significant issues described in the following section. These issues consider internal scoping and comments received from federal agencies, the SOA, individuals, special interest groups, non-governmental organizations, businesses, and a

native corporation. Each comment was reviewed and considered in defining the significant issues, other environmental and social considerations, and other considerations for plan alternatives. These will guide the analysis throughout the NEPA process. Each comment was assigned to one or two themes (e.g., young-growth transition, or climate change) so they could be easily evaluation. Additionally, each comment was given one or more of the following 12 categories relative to how the comment would be addressed (if it needed to be addressed). Comments received during the 5-year review were also considered:

- Addressed by Forest Plan and Forest Plan Land Use Designations (LUD).
- Addressed through implementation of Forest Plan standards and guidelines and Best Management Practices.
- Addressed through implementation of project-specific planning, implementation, and mitigation measures.
- Addressed during processes or impact analyses routinely conducted by the Interdisciplinary Team.
- Addressed through spatial location of alternatives.
- Used to drive or partially drive an alternative.
- Beyond the scope of the project.
- Support amendment project.
- Oppose amendment project.
- Other request or comment
- Addressed by law, regulation, or departmental direction
- Consider recommendation for analysis

6.1 SIGNIFICANT ISSUES

The following are significant issues developed during the scoping process described above, and developed in consideration of the purpose and need of this EIS. These issues are used to drive or partially drive alternatives or will be analyzed in the greatest detail in the EIS. Section 5.2 identifies other environmental considerations, which are not considered significant issues for this EIS but will also be addressed. Finally, Section 5.3 provides a summary of all comments received during scoping.

Issue 1 – Young-Growth Transition

Issue Statement: The Secretary of Agriculture requested the Forest Service to transition to a YG–based timber program on the Tongass in 10 to 15 years, more rapidly than considered in the 2008 Forest Plan. This transition is intended to move the Tongass National Forest to a more ecologically, socially, and economically sustainable forest management program and reduce old-growth harvest while providing economic timber to support the local forest products industry.

The issue concerns financial efficiency, salability, and volume of future timber sales. It also relates to the potential local employment and revenues generated for communities in the local area. YG timber growth rates, sustainable harvest rates, the amount of old-growth harvest needed during transition to sustain the timber industry, and the locations where young-growth harvest would take place are some of the factors to be considered.

<u>Units of Measure</u>

- Timber volume of young growth vs. old growth

- Acres of harvest of young growth vs. old growth by harvest and logging system by location
- Financial efficiency of young-growth vs. old-growth harvest
- Number of annualized direct jobs supported
- Timber demand vs. amount of harvest made available to meet demand

Issue 2 – Renewable Energy

Issue Statement: The Forest Plan should promote the development of renewable energy projects to help Southeast Alaska communities reduce fossil energy dependence, where it is compatible with National Forest purposes and to ensure that the planning, construction, and operation of projects protect and effectively use National Forest System lands and resources. Management of National Forest System (NFS) lands should support the intent of the State of Alaska legislature to receive 50 percent of its electrical generation from renewable energy sources by 2025 (House Bill 306 [2010]).

Units of Measure

- Proportion of known potential renewable energy projects potentially allowed under the Forest Plan

Issue 3 – Protection of Roadless Areas

Issue Statement: The protection of roadless areas (particularly high-value roadless areas) from development and timber harvest on the Tongass is of local and national importance, particularly relative to wildlife and biodiversity, recreation, and tourism. Whether or not the Tongass will be exempt from the 2001 Roadless Rule is not clear.

Many people believe roadless areas should be allowed to evolve naturally through their own dynamic processes and should be afforded protection that ensures this will occur. The Tongass includes very large undeveloped land areas with several portions of the Forest consisting of contiguous roadless areas that exceed 1 million acres and represent large, unfragmented blocks of wildlife habitat. This large scale of roadless lands does not exist on any other National Forest, except the Chugach National Forest in Southcentral Alaska.

Roadless areas are considered important because of their wildlife habitat and recreation values and their importance for tourism. They are also important because of the passive-use and ecosystem services values they provide.

Units of Measure

- Acres of inventoried roadless areas protected under each alternative
- Values of lands protected under each alternative

Issue 4 – Protection of Wildlife Habitat and the Old-growth Conservation Strategy

Issue Statement: The Tongass National Forest supports a unique and important assemblage of wildlife including the largest population of brown bears and breeding bald eagles in the world, the Alexander Archipelago Wolf, species of high importance for subsistence (e.g., Sitka black-tailed deer), an extensive array of endemic mammals, and a large number of species that are at least partially dependent on old-growth habitats (e.g., marten and goshawk). The Tongass Old-growth Conservation Strategy is considered important for the continued health of the unique wildlife and plant populations in Southeast Alaska.

Timber harvest and road development can have important effects on populations of many of these species and the biodiversity of Southeast Alaska. Although less than 10 percent of the productive old-growth habitat on the Tongass has been converted to young growth, the

percentage is much higher for certain types of old growth, such as lowland and large-tree old growth. In addition, a high percentage of non-NFS lands have been harvested at a much higher rate. Therefore, the cumulative effects of harvest and road building on wildlife in Southeast Alaska are greater than the effects for the Tongass by itself.

Units of Measure

- Acres of productive old growth protected under each alternative
- Percentage of biogeographic provinces protected in reserves
- Changes in road densities
- Indicators of habitat capability using habitat models
- Cumulative harvest and road development on all Southeast Alaska lands

6.2 OTHER ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

The following list of other environmental and social considerations will be analyzed in the EIS, in addition to the significant issues identified in the previous section.

- Air Quality
- Climate Change
- Geology, Karst, and Caves
- Soils
- Water
- Wetlands
- Fish
- Plants (including sensitive plants and invasive species)
- Forest Health
- Lands
- Transportation and Utilities
- Minerals
- Recreation and Tourism
- Scenery
- Subsistence
- Heritage Resources and Sacred Sites
- Wilderness, Wild and Scenic Rivers, and other special LUDs
- Economics and Social Environment
- Environmental Justice

6.3 FIVE-YEAR REVIEW COMMENT SUMMARY

During the comment period for the Five-Year review, 252 unique submissions were received, along with 152,182 form letters (some of which contained unique content). The range of topics, including young-growth management, the Roadless Rule, watershed restoration, mining, renewable energy, and local economies.

The Forest Service developed 515 Statements of Concern (grouped into 24 topics) based on the comments. Among the comments received, some issues were raised more frequently than others. The five SOC Topics with the most comments received were Tongass National Forest management issues, timber, Land Use Designations, socioeconomics, and energy. A detailed summary of the Five-Year Review process and comment summary is available online at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5443864.pdf (USDA Forest Service 2013)

6.4 SCOPING COMMENT SUMMARY

The following sections provide a summary of the scoping comments received, sorted by issue category. Some comments were identified as part of one or more issue categories and may be duplicated. This summary covers comments related to the significant issues as well as the other environmental and social considerations. Some comments below have been taken directly from

comments received while many have been summarized or paraphrased to represent several similar comments. All comments were considered individually. This list is not inclusive; a complete record of comments is available in the planning record.

6.4.1 Climate Change

Climate change was a common theme among many comments. Some commenters requested that climate change be identified as a significant issue. Others requested that the effects of the alternatives on the climate be considered, as well as the effect of climate change on every resource. Examples of climate change comments include the following:

- EPA recommends that the Forest Plan EIS discuss the anticipated impacts associated with past, present, and future changes in climate throughout the forest and provides suggested references.
- Please treat climate change as a significant issue in the purpose and need for this proposed amendment. All federal agencies must manage for climate preparedness and resilience (Executive Order 13653) and Secretary Vilsack has recognized the Tongass' global significance as a carbon-rich reserve.
- The DEIS needs to consider the critical temporal relationship between present carbon emissions and the future effects of climate change. The immediate release of carbon from logging will have significant impacts compared to the much longer-term release of biomass from the death and decomposition of live trees in decades or centuries.
- In addition with the carbon dioxide problem, cutting down forests only accelerates the climate problems. Don't make a short-term decision with long-term negative consequences. We have too few forests as it is.
- If we want to control global warming, we need to preserve all out healthy trees
- Analyze the effects of alternatives on carbon sequestration and long-term storage potential.
- The current Conservation Strategy fails to recognize the role of climate change in the maintenance of biodiversity. The effects of climate change must be considered if the Conservation Strategy is re-evaluated.
- The alternative that best optimizes carbon and other values on the Tongass is one that rapidly transitions out of industrial old-growth logging.

6.4.2 Economics

Many comments addressed issues or concerns related to economics. Comments concerned the economics associated with transition to YG management, the economics of the current timber program, and the economics associated with non-timber resources. Examples of economic comments are provided in the following subsections.

6.4.2.1 Transition Economics

- The analysis should evaluate the economic viability of YG management only, rather than a mix of YG and old-growth logging.
- If existing mills close, it will not be possible to maintain the economies of scale to support timber operations on the forest or to bring new operators into the region. Forest Service needs to invest in transition.
- Transition should create local jobs and require local, value-added manufacturing.
- The outcome of any "transition" alternative should reward local, value added manufacturing and end existing export and transshipment policies on the Tongass. The

successful Tongass micro-sale program that currently exists on Prince of Wales Island encourages local processing and the manufacture of high value-added wood products.
- Evaluate the economic outlook for YG forest products and analyze the need to export YG materials to build a YG program.
- Emphasize value-added forest product uses.
- The current appraisal system favors large operators and does not fully capture the value that YG timber offers the region. The system needs to be revised to encourage business investment and development, job growth, and value-added manufacturing in Alaska.
- All alternatives should focus on creating local timber jobs.
- Consider alternatives favoring management for deer and wildlife habitat, healthy salmon streams, and a local wood economy for Southeast Alaska.

6.4.2.2 Economics of Current Timber Program

- Criticism of the Tongass timber program as a market failure in which taxpayers and other forest users pay for below-cost timber program.
- Recent YG harvests have not been economical.
- The Forest Service is not meeting its annual timber targets and the lack of timber supply is responsible for decline of timber manufacturing.
- The Forest Service should update and revise its forecasts for market demand of Tongass timber. The economic analysis used by the Forest Service in its timber sale planning is inaccurate and outdated, and greatly overestimates market demand for Tongass timber.
- The Forest Service must also revise its forecasts of market demand for timber, which have consistently proved to be much higher than actual market results.
- As part of the Amendment process, the Tongass National Forest needs to revisit its methodology for estimating market demand and its series of market demand scenarios, because they overestimate actual demand.
- For YG, the Forest Service needs to move away from using export based criteria. In this land management plan, the Forest Service needs to analyze what markets for Tongass timber they are “seeking to meet.”
- Stop systematically overestimating timber demand.
- Stewardship contracts to not recoup actual cumulative effects and opportunities lost.

6.4.2.3 Non-timber Economics and Competition with Timber Program

- The DEIS should evaluate how Forest Plan Amendment implementation will impose real costs, monetary and otherwise, on non-timber forest values and give these values equal consideration.
- The DEIS needs to consider all non-timber-related economics and number of jobs supported by forested habitat including: recreation, tourism, hunting, fishing and subsistence.
- Stop giving timber a preference over other Tongass multiple uses by systematically overestimating market demand.
- Support tourism and fishing in place of logging old growth.
- The Forest Service should support local communities by seeking ways to improve protections for important fish and wildlife habitat and enhance visitor services. At the same time, the Forest Service should end its large-scale old-growth timber sale program.

- As part of the plan amendment, enact sensible budgets for recreation, heritage, and wilderness programs in the Tongass that can support diverse and sustainable economic opportunities for southeast Alaskans. We urge you to shift resources to support our growing tourism and recreation economy.
- Recreation is now bringing in more money than logging, shift the funds to it. Preserve the forests so that this remains viable.
- The DEIS should include a detailed public investment analysis that discloses the full cost of administering the TLMP timber sale program accompanied by a more thorough analysis of benefits provided by intact old growth forests to recreation, fisheries and subsistence.

6.4.3 Fish

A number of commenters addressed concerns associated with fish and fish habitat protection. Examples of comments related to fish include:

- Refocus resources and management toward projects that protect and restore vital watersheds and important fish and wildlife habitat, while promoting a diverse and sustainable economy in Southeast Alaska based on fishing, tourism, and recreation.
- Consider alternatives favoring management for deer and wildlife habitat, healthy salmon streams, and a local wood economy for Southeast Alaska.
- The EIS should describe the current quality and potential capacity of habitat, its use by fish and wildlife throughout the forest, and identify known fish and wildlife corridors, migration routes, and areas of seasonal fish and wildlife congregation.
- The EIS should evaluate effects on fish and wildlife from various management strategies as well as any proposed habitat alteration, aquatic and terrestrial habitat fragmentation caused by roads, land use, and management activities, and human activity.
- The Forest Plan currently fails in the area of demonstrating and focusing management of Tongass lands as working lands for the production of salmon. An amendment should include sufficient study to show what lands on the Tongass are producing fish, the baseline production a) currently, b) prior to industrial logging (1954), c) prior to fish traps and canneries, and d) projections into the future under various management regimes and climate change impacts. Part of the assessment should include calculations of the value of contributions to the economy from Tongass National Forest lands and management activities. An assessment should be made as to areas that need to be designated as salmon producing watersheds and well defined goals should be set for an acceleration of restoration activities to bring all salmon systems that have legacy impacts from historic industrial logging to be restored to full production capacity.
- Consider alternatives favoring management for deer and wildlife habitat, healthy salmon streams, and a local wood economy for Southeast Alaska.

6.4.4 Karst

Several comments were received stressing protection of karst landscapes. Comments relating to karst landscapes include:

- Karst protection in south Southeast Alaska should be kept in place or strengthened due to past and future corporate big tree logging, from both Native and private corporations. Karst is important for maintaining clean water and a healthy Tongass eco-system.
- Preserve all karst areas.
- The richness of our forests, with karst and muskegs and unique soil microbiology and salmon streams, is irreplaceable after logging of the old growth.

6.4.5 Lands

A number of commenters identified general concerns related to lands, as well as specific concerns related to proposed land exchanges and specific land areas. Comments relating to lands include:

- Support for efforts of the Alaska Mental Health Trust Authority and the Forest Service that resulted in the proposed land exchange document dated September 4, 2012. The proposed land swap will provide much needed timber harvest activity for the southern southeast region economy.
- Include the Trust Land Exchange as an action common to all alternatives of the Forest Plan Amendment. The Trust Land Office manages lands for the Alaska Mental Health Trust and has begun the planning process to implement the objectives outlined by Secretary Vilsack (Memo 1044-009, July 2, 2013.). It appears that the Trust Land exchange creates a positive working solution to support the Secretary's transition plan. Identifying the proposed exchange as an alternative in the forest plan amendment would promote that potential outcome.
- Recommendation to include land patterns and shared boundaries that would exist upon passage of the Sealaska legislation in the amended Tongass Plan.
- A request for analysis and consideration of other unfulfilled Native land entitlements.
- Requests specific to Traitors Cove, Southern Kruzof Island, and Connell Lake.
- A request for the federal government to turn all federal lands (within the Borough) over to the Ketchikan Gateway Borough.

6.4.6 Land Use Designations

6.4.6.1 Transportation and Utility LUD

Several comments requested modification to or clarification of Transportation and Utility System (TUS) LUD Standards and Guidelines to remove permitting and development barriers. Specifically, it was requested that the current TUS LUD should be amended to change the criteria to allow the TUS LUD to apply to hydropower projects and other renewable energy projects within TUS Avoidance Areas and to allow for public and private hydropower development in all LUDs.

6.4.6.2 Renewable Energy LUD

Several commenters requested or supported the development of a Renewable Energy Resource Plan and/or Renewable Energy LUD to facilitate the development of these projects. Representative comments include:

- A Renewable Energy Resource Plan, including a Renewable Energy Resource Development LUD, should be added to the Forest Plan to promote and support all forms of renewable energy development (including geothermal) and related transmission lines within the Tongass National Forest
- A Renewable Energy LUD that promotes the development of hydroelectric projects with a minimum of regulatory impediment and cost will be the key to a successful transition from fossil based fuels in the Tongass to clean renewable energy for all of Southeast Alaska.
- The renewable energy LUD should allow development of all clean energy technology (wind, biomass, geothermal, tidal) and associated transmission and access roads.

- Plans for and interest in hydropower development, mining, transmission, geothermal, and transportation projects exist and should be considered and evaluated in this amendment. Necessary changes to Land Use Designations and other use decisions present a management challenge that would be appropriate to consider in the LRMP revision process. We encourage the Forest Service to consider the potential for project right-of-way and siting needs, as land use determinations are established or revised. Based on this analysis, it may also be appropriate to expand upon the standards and guidelines related to land ownership to include additional standards and guidelines related to these types of activities. We recommend that the Forest Service work closely with the FWS and the Alaska Department of Fish and Game, as well as other potentially affected stakeholders, on these changes."
- Changes to further hydropower development are outside the essential core purpose of the amendment and should not be part of the amendment.

6.4.6.3 Tongass Community Economic Development Zone LUD

Some commenters requested a new Tongass Community Economic Development Zone LUD to promote and support economic development and activities for communities with lower per capita incomes or high energy prices or unemployment.

6.4.6.4 Minerals and Strategic Minerals LUD

Some commenters requested a new Mineral and Strategic Mineral LUD to promote and support mineral and strategic mineral development and related access roads consistent with national security and national strategic mineral policies.

6.4.7 Minerals

In addition to the Mineral and Strategic Mineral LUD recommended by some commenters (see Section 5.2.6.4, above), some commenters requested that the term “reasonable access” be defined for purposes of the Forest Plan to provide timely (30-day turnaround) issuance of Forest Service Special Use Permits for those who hold a mining claim or Federal Energy Regulatory Commission (FERC) preliminary permit to authorize these operations to investigate and develop lawfully permitted federal resources.

6.4.8 Old-Growth Reserves

Several comments were received specific to old-growth reserves (OGR). These comments addressed OGR design criteria, protection of OGRs, and additional evaluation of the efficacy of existing OGRs. Example comments include:

- The FWS recommends specific changes to OGR design criteria to ensure comparable conservation value within Value Comparison Units when OGRs are proposed to be relocated.
- Treatments in OGRs, beach fringe, estuary, riparian, and other buffers, or other areas important for conservation should be to improve habitat value.
- Harvests in OGRs should be designed specifically to accelerate succession to old-growth conditions and maintain non-timber resources.
- Current OGRs should be reviewed by an interdisciplinary state and federal teams to understand how they are working, consider issues associated with altering their locations and sizes, how removal of second growth stands from OGRs would affect

them, and assess how possible modifications would be expected to affect fish, wildlife, and their uses.

- OGRs appear to be located to exclude old-growth habitat (to allow for high-grade logging) avoid the most important deer winter habitat to make these areas and trees available for logging.
- The scope of the Tongass Forest Plan Amendment needs to be expanded to evaluate the entire system of old-growth reserves in order to demonstrate their efficacy. Wildlife outputs must be analyzed in the context of projected demand rather than just what is needed to meet minimum viable populations.

6.4.9 Planning/Alaska National Interest Lands Conservation Act (ANILCA)

Many comments addressed general planning issues, including the 2012 Planning Rule, the 5-year review, plan revision, ANILCA, multiple-use planning and other issues. Examples of these comments include:

- The NOI is disappointingly too broad in scope and lacks appropriate direction for the Forest Service to respond urgently to the need to phase out industrial-scale old growth logging immediately.
- We are still concerned about the 2012 Planning Rule and its impact on the ability of the Forest Service to provide a cost-effective, workable framework for national forest planning that is consistent with the National Forest Management Act and other statutory direction. The 1982 Rule was used for the 2008 plan and should be used for any amendment as well.
- Do not "test drive" the 2012 planning rule on the Tongass until other “early adopters” have had a chance to report back
- The Forest Service has yet to outline how the analysis from the five-year TLMP review makes the case for amending the forest plan to accomplish a transition to young-growth timber harvesting within the next 10 to 15 years.
- Any section of the Forest Plan amended during this planning process must also ensure that ANILCA continues to be properly recognized. To help ensure there is no confusion during implementation, we request the Forest Plan specifically acknowledge that the Forest Service intends for all Forest Plan provisions, including administrative designations and prescriptions to be consistent with ANILCA. However, in the event of a conflict, ANILCA prevails.
- Consider a process or plan to coordinate its resource harvest and other management activities with adjacent landowners
- What is needed instead of an amendment to the Forest Plan is a complete revision of the 1997 Forest Plan and 2008 Amendment. A full revision of the Forest Plan is long overdue.
- Suggest the Forest Service use an analysis approach called OPTIONS that identifies eight factors that must be addressed in order to effectively define and implement a sustainable, defensible and auditable forest management strategy.
- The scope of the amendment should be narrowed to ensure the Plan is amended during the current presidential administration.
- The YG transition should be directed to the Federal Advisory Committee Act committee and a future planning process, rather than addressed in the current plan amendment.

- It is vital that the Forest Service pare the plan amendment process down to its bare essentials. Numerous issues that could be dealt with, but can await some future process, need to be identified as non-core and deferred.
- We believe that the focus on maintaining the existing timber industry fails to provide for multiple uses. The scope of the proposed Amendment does not reflect the broad need for changes, does not reflect a realistic assessment of changed conditions, and consequently will fail to appropriately guide the achievement of ecological, social and economic sustainability in the planning area. [36 Code of Federal Regulations (CFR) 219.8]

6.4.10 Purpose and Need

A range of comments addressed the purpose and need. Examples of these comments include:

- We request that you develop a revised purpose and need for the amendment that does not prioritize timber development "over the competing environmental and recreational goals without justification sufficient to support the agency's balancing of these goals."
- The Forest Service is encouraged to consider expanding scope of analysis.
- Only limited attention should be paid to the suitability or availability of land for logging
- The amendment should focus on the goal to preserve the exceptional natural values on the Tongass, rather than the goal of ensuring that communities are economically viable.
- Apply 2012 Planning Rule. TLMP amendment should not thwart the spirit and intent of NFMA and further delay a long overdue economic analysis of all the Tongass resources.
- The Forest Service needs a new paradigm where timber is relegated to its economic value relative to other forest resources- since other forest uses are productive and above cost.
- The Amendment's limited purpose aimed at timber industry objectives falls short of the NEPA obligation to "rigorously explore and objectively evaluate all reasonable alternatives." [40 CFR. § 1502.14(a)]. You could fix this problem by either focusing narrowly on alternatives that immediately end old-growth logging, or by broadening the scope of the Amendment by developing alternatives that enhance recreation opportunities in the Tongass National Forest and alternatives that focus on mitigating damage to salmon habitat through an emphasis on completing deferred road maintenance.

6.4.11 Plants

Some comments were received stressing that the EIS evaluate impacts on plant species, their habitats, and invasive species.

6.4.12 Recreation and Tourism

Several comments were received stressing the importance of other industries, including recreation and tourism, to the economic opportunities of communities. Some suggested the Forest Service should reallocate its priorities and resources to support these industries and stop giving timber a preference over them.

6.4.13 Renewable Energy

Many comments addressed renewable energy. Some of these comments were general in nature, and many dealt with hydropower or biomass. Examples include:

- The EIS should consider alternative investments in efficiency programs, wind turbines, tidal energy, and solar and thermal energy.
- The Forest Service should solicit information from the renewable energy industry with regard to potential renewable energy sites and utilize that information in the identification of specific areas within the Renewable Energy Resource LUD within the Forest Plan.
- Roadless area restrictions negatively impact access to and development of renewable energy, in conflict with state and national goals for clean energy
- Ensure that Renewable Energy Resource Policies are promptly included in the Forest Plan without the needed for a Plan amendment process.
- The Draft EIS should assess the social and economic impacts of renewable energy development
- The amendment should address the needs relating to developing renewable energy resource on the Tongass National Forest to the maximum extent possible.
- Recommends that the Plan amendment process be utilized to level the playing field for consideration of renewable energy with other important resource values within the TNF.
- The renewable energy component of the plan should encompass both ongoing maintenance requirements and the evaluation and development of new renewable energy resources.
- The Forest Plan EIS should consider expansion of existing and development of future renewable energy facilities and transmission lines.
- Lands permanently cleared for a Renewable Energy project should be considered unsuitable for timber production.
- A Renewable Energy Resource Plan, including a Renewable Energy Resource Development LUD, should be added to the Forest Plan to promote and support all forms of renewable energy development (including geothermal) and related transmission lines within the Tongass National Forest

6.4.13.1 Hydropower

- The Forest Service should modify the Tongass Forest Plan in a manner which allows for hydropower development within the Tongass National Forest, and provides for equal treatment of hydropower development proposals regardless of market location or funding source.
- The Forest Plan should consider all known potential hydroelectric energy sources located in the Tongass National Forest and provide for their future development.
- Incorporate Lake Grace Hydropower into the Forest Plan.
- Changes to further hydropower development are outside the essential core purpose of the amendment and should not be part of the amendment.
- We support development of fish-friendly hydropower to meet local power needs in southeast Alaska, and the Tongass Plan already makes ample provision for it.

6.4.13.2 Biomass

- Conversion to biomass for heat and/or potential energy generation is fatally flawed. The Draft EIS should disclose impacts to human health and carbon sequestration, as well as the cost to taxpayers

- To consider alternatives that redirect the public investment in alternative energies to cleaner and real renewable energy sources, not biomass. Federal investment in biomass facilities is a lost opportunity cost that will divert funds from energy alternatives that can better meet the region's needs
- The EIS needs to evaluate the life-cycle greenhouse gas emissions associated with biomass industry development
- The Forest Plan should consider biomass heating and energy systems and the potential to manufacture biomass-based fuels.
- The EIS should evaluate health risks associated with increased utilization of biomass for energy and heat.
- Recommends the inclusion of biomass as a forest resource.

6.4.14 Restoration

A number of comments concerned forest restoration, watershed restoration, and restoration projects in general. Examples of the comments include:

- A Plan "standard" that discloses the costs of restoration projects in all timber sale planning documents must be adopted in the Amendment.
- We request that the EIS consider reasonable alternative funding mechanisms for habitat amelioration projects rather than an exclusive focus on so-called "stewardship" contracting. [40 CFR. § 1502.14(a); Sierra Forest Legacy, 577 F.3d at 1025 – 1027]. The Tongass National Forest has never provided a NEPA analysis that evaluates the feasibility of stewardship contracting or alternative ways to fund projects for habitat mitigation and other remedial forest management needs. Programmatic analysis may show that it would be more cost-effective to emphasize service contracts for road storage and decommissioning and red pipe remediation, rather than to liquidate old-growth forests in order to fund perceived needs for remedial work.
- Refocus resources and management toward projects that protect and restore vital watersheds and important fish and wildlife habitat, while promoting a diverse and sustainable economy in Southeast Alaska based on fishing, tourism, and recreation.
- The need to work on forest restoration, which duplicates the natural condition rather than uniformed canopied, second growth tree farms.

6.4.15 Roadless Areas

Many comments addressed roadless areas. Some comments were of a general nature, many supported preserving roadless areas, and many supported exempting activities from the roadless rule. Examples include:

- Analysis should consider how the forest should be managed with Roadless Rule not enforced and also if it remains in force.
- LUDs that allow logging in inventoried roadless areas (IRA) should be revised.
- Roadless area restrictions negatively impact access to and development of renewable energy, in conflict with state and national goals for clean energy
- Updating the roadless area inventory is fine for the amendment exercise, although it may or may not be pertinent.
- The Forest Service should not consider IRAs as a determining factor for amending LUDs or defining the suitable and available land base. Update the inventoried roadless area maps to omit roaded portions (i.e., "roaded roadless" areas) due to their substantially altered condition.

- Possible rulemaking related to roadless areas should not be allowed to complicate the transition amendment.
- The amendment should not include an update to the inventory of roadless areas.
- Decisions regarding IRAs should be addressed in a separate process.

6.4.15.1 Preserve Roadless Areas

- Opposes roads in roadless areas.
- Conservation of inventoried roadless areas should be a significant feature of all transition alternatives.
- The plan amendment is not a prudent vehicle for decisions about Tongass roadless areas.
- The Forest Service was encouraged to update its LUDs to remove inventoried roadless areas from the suitable timber base.
- Conservation of inventoried roadless areas should be a significant feature of all transition alternatives.
- If rulemaking is needed it should address only the simple issue of supplying a missing end-date for the self-described “temporary” exemption of the Tongass from the Roadless Area Conservation Rule. The effects analysis in the EIS for the transition amendment should assume that roadless areas will not in any likely scenario be logged.
- Conservation of inventoried roadless areas should be a significant feature of all transition alternatives.

6.4.15.2 Favors Exemption to the Roadless Rule

- Consider amending the Roadless Rule as applied to the Tongass to permit the development of geothermal power, transmission lines, and access to them.
- The Forest Service should engage in rulemaking to once again exempt the Tongass National Forest from the 2001 Roadless Rule.
- The Forest Supervisor and District Rangers should have the authority to permit development in IRAs.
- Suggests modification of Roadless Rule to open up viable timber.
- Modification to Roadless Rule needed to allow hydropower.
- Modification to Roadless Rule needed to provide reasonable access to mines.
- Recognize the negative impacts incurred by the restrictive access in roadless areas to critical resources within the Ketchikan Borough.
- The EIS should consider appropriate road access in IRAs for timber harvest and other management activities, mineral development, and renewable and alternative energy
- Implementation of the Roadless Rule in Alaska violates ANILCA.
- The Roadless Area Conservation Rule should not inhibit hydropower development in the Tongass.
- The Roadless Area Conservation Rule, as an administrative regulation, does not affect hydropower applicants’ ability to seek roads pursuant to the Federal Power Act.
- Resolve ambiguities in the preamble to the 2001 Roadless Rule, as applied to the Tongass, regarding the Forest Service's authority to permit new hydropower facilities, transmission lines and access to them for which application is made after January 12, 2001.
- Supports Tongass exemption from 2001 Roadless Rule.

- Limits on access to the Tongass, due to continued application of the 2001 Roadless Rule, impede SEAPA's ability to access its facilities to provide core maintenance and also hinders the key work necessary to plan and develop future energy resources.

6.4.16 Special Uses

Several commenters requested methods to streamline special use permitting for those that hold a mining claim or FERC preliminary permit to authorize these operations to investigate and develop lawfully permitted federal resources. These methods included providing a 30-day review and issuance of Special Use Permits for exploratory and study activities.

6.4.17 Subsistence

Several commenters stressed the protection of continued subsistence uses on the Forest. Examples include:

- The Tongass Plan EIS should evaluate the best methods and processes for monitoring, researching, and sustaining fish and wildlife resources in the Forest.
- The Forest Plan must provide for continued subsistence and sustainable harvest of national forest resources
- Subsistence uses need to be factored into Tongass Forest Plan land use planning from the very beginning of the process.
- The EIS should consider road access to resources for subsistence, recreational, cultural, and social activities important to the southeast communities.

6.4.18 Timber

Many comments were assigned to the timber theme. Some supported an immediate or rapid end to old-growth logging, or opposed clearcuts or logging on the Tongass in general. On the other end of the spectrum, some supported more timber harvests. Example comments include:

- The Forest Service should quantitatively consider how timber harvest can be accomplished while supporting sustainable populations of fish and wildlife that are managed for a variety of uses.
- Harvest of old-growth wood in selective harvest regimes and/or wildlife thinning needs to be monitored for windthrow and for long-term effects and benefits.
- The Amendment process must revisit, in particular, plan components that allow clearcutting and plan components that allow for clearcuts larger than 100 acres. Tongass Forest Plan standards and guidelines for clearcutting need to reflect and appropriately balance impacts to other resources.
- Request for substantial reduction in lands currently deemed suitable for timber production and that the Forest Service develop alternatives that provide primarily for non-timber uses.

6.4.18.1 Reduce Old-growth Harvest and Clearcutting

- Preserve old growth; protect all remaining old-growth forests.
- Leave all remaining old growth in the Tongass for the next generations.
- Use selective logging practices - not clear cuts.
- Clearcuts contribute to erosion, flooding, establishment of nonnative and particularly invasive and noxious vegetation.
- Stop logging the beautiful rainforest of Alaska, the Tongass National Forest.
- We should be phasing out old growth logging altogether.

- Stop old growth logging. These forests act as a carbon sink and natural water purification system.
- Old growth forests cannot be replaced simply by planting more trees after logging.

6.4.18.2 Increase Harvest Levels

- The Forest Service should make available at least 350 million board feet (MMBF) of timber annually.
- Any further removal of Tongass lands from the approved timber base violates ANILCA.
- Need to provide the lumber needed to build houses.
- Please increase old-growth logging immediately. Please support a dual transition in which a firm Allowable Sale Quantity is split between old-and second-growth components. Old-growth allowable sale quantity (ASQ) should be increased drastically and immediately.
- Proposes timber preference over other forest uses.

6.4.19 Transportation

Transportation-related comments include those that encouraged keeping roads open to access YG or other resources, addressed water quality or maintenance concerns, or requested specific actions, like recognizing proposed roads. Example comments include:

- Stop removing existing road systems that will be needed to harvest YG in the future.
- Recommendation that the road and trail system evaluated through the Forest Plan reflect realistic, long-term funding expectations. The NEPA analysis for this planning process should discuss resources available to build and maintain the road and trail system. Please indicate the likelihood for adequate maintenance funding for each of the action alternatives.
- Plan should recognize a land access route to Blank Inlet, providing economic and recreational opportunities important to the Ketchikan Borough.
- Encourages the Forest Service to amend the Forest Plan to recognize the proposed Vallenar Bay Road and include it on the LUD map.
- Plan amendment should take into better account updates to the State of Alaska's Southeast Transportation Plan and the Alaska Energy Authority's 2011 Southeast Regional Integrated Power Plan.
- Action alternatives should not propose changes to the Forest Plan that may affect existing roads or other transportation facilities.
- The EIS should consider road access to resources for subsistence, recreational, cultural, and social activities important to our southeast communities.
- The current Tongass Forest Plan fails to provide standards to adequately assess and make known the impacts of existing roads and proposed project road activities on watersheds, riparian areas, streams, and fish habitats.
- The Forest Plan should be updated to include a non-negotiable standard of every Tongass timber project planning process, for assessments of road-stream connectivity and consequent impacts on peak flows and sediment delivery from roads.

6.4.20 Tribal Consultation

One comment noted that the Plan should provide a framework for Alaska Native Corporation and Tribal participation in implementing access, subsistence, and other important provisions of ANILCA. Additionally, EPA provided direction for conducting intergovernmental issues with federally-recognized tribes.

6.4.21 Water

Some comments stressed the protection of watersheds and streams and requested the strengthening of Forest Plan requirements to emphasize protection. Example comments include:

- The forest must also place more emphasis on project level impairment to watersheds.
- Recommendation that Forest Plan revisions address a framework for project level watershed and water quality analysis. The EIS should summarize existing baseline watershed and water quality conditions.
- Concern over effects of management actions on drinking water sources and lists requests for the EIS to identify.
- Concern over effects of management actions on surface water quality.
- Requests revisions to standards and guidelines for stream protection and watershed health associated with road-stream connectivity.
- Various watersheds have been identified as especially important for fish and wildlife, and should be identified as unsuitable for timber harvest.
- Protect drainages that are crucial for healthy habitat.

6.4.22 Wildlife

Several comments provided wildlife concerns or management recommendations. A common theme was the protection of Alexander Archipelago wolf. Example comments include:

- Recommendation for use of an advisory committee of expert biologists for development standards and guidelines to maintain wildlife populations.
- Recommendation that standards designed to conserve wolves (and deer habitat) should be strengthened to reduce vulnerability of wolves.
- Current Forest Service old-growth logging practices harm habitat and threaten wolf populations.
- Recommendation to use the best available information, including work of the Interagency Wolf Task Force.
- FWS requests clarification of when permits are needed for eagle nest disturbance, requests to participate in focal species discussion with Forest Service staff, and provides specific measures for the protection of goshawks.
- Concern for other species, including pollinators (e.g., bees, bats, and butterflies), marbled murrelets, Queen Charlotte goshawks, marten, bears, flying squirrel and their habitat.
- Impacts to subsistence.
- Requests that any changes to Management Indicator Species (MIS) be made in a separate amendment process directed specifically at wildlife conservation and peer-reviewed by an independent scientific panel, or part of a full Forest Plan revision.
- Recommendation that the Conservation Strategy not be weakened in any way that could reduce species viability or increase risk to vulnerable species. Any modifications should be peer reviewed.
- Consider alternatives favoring management for deer and wildlife habitat, healthy salmon streams, and a local wood economy for Southeast Alaska.
- The Forest Service should meet future demands for fish and wildlife-beyond providing for minimal viable populations.
- Forest Service should review the existing Forest Plan conservation strategy using an interdisciplinary approach.

- The EIS should describe the current habitat capacity and identify known wildlife corridors, migration routes, and congregation areas and evaluate the effects of the alternatives upon these.
- The EIS needs to evaluate timberland suitability determinations in terms of the cumulative loss of habitat that has occurred due to high-grading the better quality old growth forests that provide optimum fish habitat and winter carrying capacity for deer. We request that your analysis:
    - disclose the cumulative effect of continued high-grading across the southern Tongass and discuss ending the practice;
    - assess potential impacts of any reasonably foreseeable future high-grading on all land ownerships;
    - consider high-grading at multiple scales and by different land ownerships in light of remaining large-tree productive old growth at the stand level relative to past selections of large tree and high value species and future harvests of these species, at the landscape scale and at the biogeographic landscape scale.
- Potential changes to the conservation strategy should be outside the scope of the plan amendment.
- Replacing MIS with focal species should be outside the scope of the plan amendment
- Requests to develop alternatives that maintain well-distributed populations of focal species across the Tongass, including those in prior forest plans as MIS.
- Consider alternatives favoring management for deer and wildlife habitat, healthy salmon streams, and a local wood economy for Southeast Alaska.

6.4.23 Young-Growth Transition

Numerous comments addressed the transition to young growth. Varying suggestions for old- and young-growth harvest levels over time, methods to open up YG, and suggestions for where timber should come from were received. Example comments are provided in the following subsections.

6.4.23.1 Need More Rapid Transition to Young Growth

Many comments were received that supported a transition away from old-growth harvests but at a rate faster than 10 to 15 years. Some supported an immediate stop to old-growth harvest while others recommended the transition be completed as soon as possible, in 2 years, or no more than 5 years or faster than 10 years. Example comments include:

- Support a dual transition in which a firm ASQ is split between old- and second-growth components. Old-growth ASQ should be reduced drastically and immediately. The young-growth component should support ecological, economic, and community health linking restoration and stewardship with local wood product manufacturing.
- Delaying the transition for another 10-20 years or more will result in unacceptable risks.

6.4.23.2 Culmination of Mean Annual Increment (CMAI)

Some comments suggested relaxation of the CMAI standard, or a limited relaxation if necessary to facilitate the young growth transition. Others commented that the transition should be delayed until more young growth has reached CMAI and allow old growth to be harvested in IRAs in the interim or that CMAI relaxation is not needed to secure the desired reduction in old-growth logging.

6.4.23.3 Effects on Local Industry and Communities

Concerns were raised about the effects of a premature transition to young growth on local mills that would require retooling. Others expressed support for small, value-added mills in communities.

- Support small value-added mills in our communities. Do not support export-oriented, industrial-scale, old-growth clearcuts.
- A premature transition to YG will force mill closures because inadequate supplies are available and the transition would require total retooling of existing sawmills.
- The current timber industry can be maintained through the transition through implementation of the Tongass Integrated Plan (February 2013).
- Request for alternatives favoring jobs, sustained yield forestry, and a viable wood products industry based on 10-year contracts.

6.4.23.4 Location of Young Growth Harvests

- The Forest Service should consider restricting logging, from the time of the Record of Decision on, to a subset of the current roaded, suitable, and available timber base to reduce potential impacts to other resources.
- Long-term availability of YG should be addressed later. In the meantime, YG harvest should be limited to non-controversial LUDs and YG should be separately stated (and capped) from old growth.
- YG logging should avoid prime wildlife habitat.
- Post-transition YG logging should be restricted to a subset of the current suitable and available land base that the agency identifies as least likely to entail significant environmental risks. Obvious exclusions, which could be implemented either through standards and guidelines or changes to the designated timber base, include roadless areas, karst lands, and high value deer winter habitat.

6.4.23.5 Harvest Volume

- Forest Service will have to offer substantially more than its recent average of timber and will have to build up a stockpile of sales so that commercial financing for a timber industry can be attained.
- Reassure the existing timber industry that the Forest Service is committed to providing sufficient old-growth timber for a long enough period to permit private commercial-bank financing to pay for new mill equipment and to fund the expense of pioneering new markets for young-growth timber- all steps vital to support an Alaska timber industry.
- A transition plan for YG that does not provide sufficient timber would violate the requirement of the Tongass Timber Reform Act to seek to meet the demand for timber.
- It is unrealistic to expect a widespread YG transition to begin within the next 20 to 30 years, without continued old-growth sales to make such a transition economic.
- The ASQ should be revised to reflect the sustainable young growth timber base and small old growth sale program.

6.4.23.6 Other Young Growth Transition Comments

- Industrial-scale old-growth logging projects are in complete contradiction to the original transition plan.
- All transition alternatives should focus on creating Alaskan jobs using Alaskan wood for available markets.

- The current planning process should consider timber growth rates, the landscape logging can occur on, the consequences of logging on ecosystem function, and the overall goals of Tongass management activities and how they balance with the strategic goals of overall Forest Service land management
- The Forest Service should give consideration to conservation strategies for young growth resources and how these stands can be managed to provide for adequate, economically viable timber harvests while conserving and facilitating fish, wildlife, and their uses.
- Transition alternatives should focus on the least vulnerable types of forest – red alder, conifer second growth, and cedar dieback.
- Lands that would be opened up for YG have better use if left to evolve into old-growth habitat.
- Both young- and old-growth timber programs are poor vehicles to stabilize communities. The Tongass Forest Plan amendment must evaluate all other alternatives to diversify and strengthen local economies
- Postpone transition decision until results of YG inventory are available.
- USFWS recommends establishing limits on the volume of old growth that may be cut in any year, with declining volumes allowed in subsequent years.

7.0 REFERENCES

USDA Forest Service. 2013. Five-Year Review of the 2008 Land and Resource Management Plan: Public Outreach and Comment Analysis Report. November 2013. Available online at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5443864.pdf

APPENDIX B
MODELING AND ANALYSIS

Appendix B

Modeling and Analysis

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Appendix B
Modeling and Analysis

Planning Situation

The National Forest Management Act of 1976 (NFMA) directs each National Forest to prepare a comprehensive land and resource management plan. The Tongass National Forest produced its first comprehensive Plan in April 1979. The NFMA also directs that these management plans be revised at least every 15 years. The Tongass began the Revision process in 1987, published a Draft Environmental Impact Statement (DEIS) in June 1990, and prepared the Supplement to the DEIS (SDEIS) as a result of the November 1990 Tongass Timber Reform Act (TTRA). The SDEIS was published in August 1991 and the Revised SDEIS (RSDEIS) was published in April 1996. The Final EIS (FEIS) for the Forest Plan Revision was published in 1997 along with a comprehensive Appendix B that detailed the analytical process followed. In 2002 a Draft Supplemental EIS (SEIS) was published and in 2003 a Final SEIS was developed; an Appendix B for modeling and analysis also accompanied the Final SEIS. In 2008, the Forest Plan was amended and another Appendix B was developed for the FEIS (2008) to describe the major analytical processes and models used in the 2008 Forest Plan Amendment EIS. This Appendix B is also designed to include descriptions, which document the analytical processes and models used for the 2016 Forest Plan FEIS.

Due to the magnitude (17 million acres) and complexity (e.g., 19 land use designations) of the planning process, a number of analytical methods are used. This discussion includes basic assumptions, modeling components and inputs, rules, methods, and constraints. The information supplements the broader, less technical descriptions included in the body of Chapters 2 and 3 and Appendix C of the EIS. Additional information and documents used in the analysis process are contained in the planning record. The planning record in its entirety is incorporated here by reference.

Forest Management Modeling

Analysis-related Changes between the 2008 and 2016 EISs

As the assessment, development, and analysis of geographic information is a continuous process, aspects and attributes of existing databases are continually changing. These improvements and additions to the databases often have direct results on models, model results, and the assumptions used within the models themselves. A wide range of changes and updates were incorporated during the years between the 1997 FEIS and the 2008 FEIS. These covered changes to resource inventories, coefficient development, and assumptions, all of which played a role in the recalculation of alternative outputs. Appendix B to the 2008 FEIS includes a description of these changes. This section describes the changes that occurred since the 2008 FEIS. They include:

Recalculation of the Suitable Land Base for each Alternative—More accurate information about the landscape has been captured in the Forest's GIS resource layers (e.g., streams, slopes, karst). This information was used to update the suitable land bases. In addition, the model used in the identification of suitable forest lands was refined. See Appendix A of the Forest Plan and Chapter 3 of this FEIS for more detailed information on how more current information was included in the suitability analysis.

Changes to Scenery Management System— Scenic Integrity Objectives were mapped for each alternative, based on Seen Areas, Distance Zones, and Land Use Designations (LUDs). Seen Areas and Distance Zones are based on modeling of these using Visual Priority Routes and Use Areas (see Appendix F in the Forest Plan). The Visual Absorption Capability was remodeled and mapped and based

on updated GIS layers. Regulation Class layers (see below) were developed for use in Woodstock modeling.

Land Adjustments—Since 2008, a number of land adjustments have occurred; foremost among these are the land adjustments resulting from Public Law 113-291 in 2014. These adjustments have been incorporated into the current analysis as they have affected the total National Forest System (NFS) land base as well as the suitable forest land bases.

Inventory and Data—The inventory step of the planning process consists of the collection, development, and documentation of data to address the public issues, management concerns and resource opportunities, and planning criteria. Two basic types of information are needed to facilitate the analysis and development of alternatives. The first consists of information related to the classification of land into categories with unique properties. This classification can be based on any attribute significant to planning issues. This type of information is tied directly to the map base. In the case of the Tongass National Forest, this map base is its GIS database. The second type of information is not directly tied to a map base, but has more to do with the estimation of how land will respond to certain management activities. This type of information comes from many sources: Regional procedural handbooks, research studies, available literature, etc. The most up-to-date and verifiable information available was used for the EIS. Several Forest-wide inventory data sources have been updated and improved for the 2016 FEIS. The primary changes and updates to the inventory, data, and modeling include:

- The timber harvest map was updated to reflect timber harvested through 2015.
- The inventory of young-growth forest stands was updated.
- Forest Planning and Projection System (FPS) model runs were conducted to estimate young-growth yields, including commercial thins. These runs were based off of a combination of FIA and stand-level data collected on young-growth stands.
- New site index information was developed for all stands, young growth and old growth.
- New roads were added to the roads data base.
- Changes in land ownership due to conveyances to the state and Native corporations and other adjustments were addressed in the data base (noted above).
- Improvements and updates were made to most other resource databases, including suitable lands for timber production, streams, slopes, karst, and other data.

The major modeling changes were:

- The forest management model was built using Woodstock, replacing the Spectrum model used in the previous plan (2008).
- The forest management model was run for 20 five-year periods.
- Analysis areas were defined using attributes not used previously (e.g., beach buffers, karst, etc.)
- The updated Tongass young-growth timber inventory was used to model the young-growth land base. The Woodstock model maintained stand-level detail for the young-growth acres. Old-growth acres were modeled as strata per the 2008 planning analysis.
- All timber values were recalculated to reflect current information.
- Watershed constraints were recalculated based on the suitable acres in each alternative.
- Logging costs for young growth were calculated based on stand characteristics, using the equations from the Region 10 appraisal spreadsheets.
- New treatment options including group selection/patch cuts and variable retention harvest were developed in some alternatives

- Minimum rotation ages were established based on log-product objectives, in some alternatives.
- Harvest levels were established at a pre-determined target during the period of transition from old-growth to young-growth harvest.
- A broader array and definition of land allocation constraints were developed.
- Tongass National Forest acres transferred under Public Law 113-291 were removed from the model and do not contribute to the outputs, benefits and costs discussed in the EIS.
- Haul costs were modified to include the costs of constructing and maintaining log transfer facilities; camp and commute costs were also added to remote VCUs.

The Forest Planning Model Woodstock

Woodstock is a commercially available forest management modeling system developed and sold by RemSoft (www.remsoft.com). It is widely used by private, state, and federal land managers to develop and evaluate long-term timber harvest schedules designed to meet management objectives given constraints or limitations on management activities. Woodstock allows planners to create a detailed forest management model with the available data. In this planning effort, Woodstock was used to ensure that land allocations and output schedules for alternatives are realistic and meet standards and guidelines in a cost-efficient manner.

Woodstock is similar to Spectrum, the modeling system used in the 2008 Forest Plan. Both are linear programming models that assume that relationships between outputs and the land base are linear (e.g. harvesting twice the number of similar acres yields twice the timber volume). A management objective is specified (e.g., maximize present net value of revenues from harvest) as well as any constraints that may affect that objective (e.g., land allocations, limits on harvest flow over time, limits on silvicultural choices, etc.). An in-depth technical discussion of linear programming and its use in forest management applications can be found in Davis et al. (2001).

Woodstock was used instead of Spectrum for several reasons:

1. Woodstock has a greater capacity than Spectrum. This allowed the use of stand-specific yields for the approximately 8,400 young-growth stands. Greater capacity also provided for a single model for suitable Tongass National Forest lands, as opposed to the three Spectrum models to cover the same land base.
2. Woodstock provides more capacity and flexibility in specifying yields. For the young-growth yield tables, for example, volumes were split into five species groups and four size classes. The yield tables also contained logging costs specific to stand conditions.
3. Woodstock provides more control for modeling. For example, minimum rotation ages could be established such that each stand reached 95 percent of CMAI.
4. Woodstock provided the solution in both a tabular and a spatial format that was used to drive other models.
5. A previous Woodstock model offered a good starting point. Before beginning work for the Tongass National Forest, the modeling subcontractor had already built a Tongass Woodstock model under contract to The Nature Conservancy. Most of that model had been constructed in coordination with Tongass National Forest staff. It was easier to convert that model to use for the Tongass than to start over with a new program.

The Woodstock solution process involves three steps: 1) create a linear programming (LP) model, 2) find the optimal solution to the LP model, and 3) prepare reports of the model solution. Woodstock's matrix generator portion translates the management objective, constraints and assumptions about the land base into a matrix of coefficients that can be solved with Mosek – a commercial LP solver software package. The solver software identifies a set of management prescriptions that results in the highest possible

objective function value (e.g., Net Present Value) within the constraint parameters (meeting desired conditions and appropriate standards, guidelines, and land allocations). Woodstock's report writer portion then translates the LP output into reports, such as costs, revenues, landscape condition, and long-term sustained yield capacity. For some alternatives, Woodstock's spatial solution generator was used to map the solution for use in other analytical tools.

Results from the modeling process are only approximations of what to expect when any given alternative is implemented. The main purpose of modeling is to aid planners in estimating likely future consequences of management decisions. An informed choice between alternatives can be made even though the model may lack precision in describing specific attributes of a given alternative.

The Tongass Woodstock Models

Large LP models can be difficult or impossible to solve. While the Woodstock model offers more capacity than the Spectrum model, some of the limitations of the previous Spectrum models were imposed on the Woodstock model. Specifically, the Woodstock models for the Tongass only analyze land classified as suitable for timber production. Those lands considered "not suitable" for timber production were omitted from the models since there were no opportunities to schedule management activities. The process for determining suitability can be found in Appendix A, " Identification of Lands as Not Suitable and Suitable for Timber Production," of the Forest Plan.

Woodstock Model Components

A Woodstock model has five main components: 1) the objective function, 2) land base development types, 3) management prescriptions, 4) activities and outputs, and 5) constraints. The objective function provides the model with a way to evaluate management options. Examples of typical objective functions are "maximize net present value," "maximize timber volume," and "minimize cost." Only one objective function can be used for each model run; however, forests typically find it beneficial to use the results of one objective function run to learn about the specific nature of their management problem or to formulate desired conditions used with another objective function. Detailed information on objective functions used by the Tongass is found in the solution process section of this appendix.

The management prescriptions and constraints influence how the land base will be defined. The Tongass models are designed to analyze the activities and outputs associated with timber harvest scheduling; therefore, the land base is defined by those characteristics significant to the timber resource. Other resources are dealt with through the LUD allocation process and model constraints. The management prescriptions applied to the Forest differ by types of regimes, rotation age and dispersion amount (portion of the trees removed from the stand). The costs associated with timber harvesting are documented below as are the volumes and value of the wood fiber. The constraints differ by alternative but often refer to a particular timber classification, specific geographic area, activity or output volumes allowed, and management allocation. Constraints are used to ensure desired condition achievement, compliance with appropriate standards and guidelines, and that the resultant management strategy is feasible.

Vegetation Inventory

The Tongass Geographic Information System (GIS) library was used as the source of all spatial information used in the forest management model. The timber inventory came from two sources:

Old-Growth Inventory – The Woodstock model used the same old-growth inventory data that was used for the 2008 Forest Plan, with the updates described above. Specifically, 15 strata are used to define timber volumes and yields. They span 3 stocking levels and 5 geographic ranges.

Young-Growth Inventory – Inventory projections for the young-growth acres were based on the young-growth stand-based inventory, and the recently completed site index layer. There are about 8,100 young-growth stands in the Tongass inventory. About 40,000 cruise plots were established in a subset of the young-growth stands, distributed across the forest. Plot data was compiled and average stand conditions expanded to establish inventory on the un-cruised stands

using strata based on District, size class and density class. Each stand was grown forward with the FPS growth model, using the site index specific for that stand. At each five-year period, the stand table was merchandized into six species groups and four size classes.

Land Base Analysis Areas

Analysis Areas represent unique combinations of the different Identifiers used to stratify the mapped suitable land base. The mapped suitable land base is different for each alternative and is displayed in the EIS. The total land base analyzed amounts to almost one million acres. It is important to note that they include the unmapped unsuitable lands accommodated for by the Model Implementation Reduction Factor (MIRF – see below for detailed discussion). If information was perfect, and all unsuitable lands could be mapped, the actual suitable would be somewhat less than the land base represented by the analysis areas.

An analysis area is an operational aggregation of land resource polygons that have the same characteristics, are expected to have similar responses management prescriptions, and have similar costs and benefits associated with management prescriptions. By an extension of this logic, analysis areas differ from each other in management prescription response and the costs and benefits associated with those prescriptions. Analysis Areas are unique combinations of the Analysis Area Identifiers described below.

Analysis Area Identifiers. Fourteen attributes were used to classify the land base for the Woodstock models. An analysis area is a unique combination across all attributes. The attributes describe characteristics that: (a) affect timber growth and yield; (b) describe the existing timber stand; (c) affect timber management costs and/or revenues; (d) affect land allocation and/or management restrictions in some or all alternatives. The attributes are described below.

Stand ID: Existing inventories were used to produce current and future yield values for all current young growth stands. These yields were stand based and referenced by Woodstock using the Stand ID.

Old Growth Strata: There are 15 strata assigned to the old growth stands. They span 3 stocking levels and 5 geographic ranges. In lieu of yield produced at the individual stand level, yields for old growth stands are assigned to each of these 15 strata.

Regulation Class: Regulation class is determined by the combination of Scenic Integrity Objective, LUD designation, Distance Zone and Visual Absorption Capacity. Regulation class affects the intensity of potential harvesting activities and is used to assign management regimes.

Site Class: There are nine site index classes utilized in this model. The primary use of site index is by the growth model when generating future yields. The site index was also used to establish minimum rotation ages. All site indices are base age 50, and correspond to the site productivity values in FPS.

Timber Phase: Old growth strata and young-growth stands can be categorized in one of 3 land phases, based on the Tongass Timber Sale Adaptive Management Strategy. All alternatives can access timber in Phase I and some alternatives can access timber in Phases II and III as well.

District: There are 10 districts in this model. District is used for both reporting and for assigning regeneration yields. Northern districts did not include cedar as a part of the regeneration species mix, while those in the southern districts did.

Steep Slopes: Slopes over 72- percent are considered oversteepened. In some alternatives, management is restricted on oversteepened slopes.

Land Use Designation (LUD): There are five LUD classifications in this model. The LUD is a factor in identifying appropriate management regimes.

Road Classification: Road classification specifies whether an area is presently roaded or unroaded. The roaded/unroaded condition of an area influences the cost of harvesting the timber and is used to determine appropriate management. Unroaded areas require more costly road construction; roaded areas require less costly road maintenance and repair when harvesting activities are conducted.

Riparian Management Area: Riparian management area (RMA) is used to assign management regimes in some alternatives.

Beach Buffer: Stands that border saltwater are designated as within the beach and estuary fringe (also referred to as beach buffers). Beach buffers are used to assign management regimes. In Alternative 5, a 200-ft fringe right along the water is never planned for treatment. These stands received a 21-percent reduction in acres to account for a fringe area right along the water that will never be assigned management in any alternative addressed by this model.

Karst: Karst landscapes have been categorized as low, moderate, and high vulnerability. Karst is used to assign management regimes.

Value Comparison Unit (VCU): VCUs, which generally represent large watersheds, are used to assign hauling costs. VCUs are also used to disperse harvest across the landscape

Logging System: Logging systems consist of the three basic categories of ground, cable, and helicopter. Cable and helicopter have additional levels depending on yarding distance. Logging systems are used to assign logging costs.

Table B-1
Woodstock Themes

Theme	Attributes
Old Growth Strata	North Island Low Volume North Island Medium Volume North Island High Volume North Mainland Low Volume North Mainland Medium Volume North Mainland High Volume South Island Low Volume South Island Medium Volume South Island High Volume South Mainland Low Volume South Mainland Medium Volume South Mainland High Volume Yakutat Island Low Volume Yakutat Island Medium Volume Yakutat Island High Volume
Regulation Class	Ineligible for management Reg Class 1 Reg Class 2 Reg Class 3
Site Class	SI 1 to 35 SI 36 to 45 SI 46 to 55 SI 56 to 65 SI 66 to 75 SI 76 to 85 SI 86 to 95 SI 96 to 105 SI > 105

Table B-1 (continued)
Woodstock Themes

Theme	Attributes
District	Admiralty Craig Hoonah Juneau Ketchikan Petersburg Sitka Thorne Bay Wrangell Yakutat
LUD	Modified Landscape Old Growth Reserves Scenic Viewshed Timber Management All Others
Roadless	Roadless between 1000 and 5000 acres Roadless less than 1000 acres Inventoried Roadless Area – non-roaded Inventoried Roadless Area – roaded Roaded
Karst	None Low Vulnerability Medium Vulnerability High Vulnerability Unknown
Logging System	Ground Cable Short span Cable Long span Helicopter Distance <0.75 Mile Helicopter Distance 0.75-2 Miles Helicopter Distance >2 Miles

Modeled Analysis Areas. Using the 14 attributes, there were about 120,000 unique combinations of acres. Many of these analysis areas were small and we eliminated small polygons in order to make the model run more efficiently. Young growth analysis areas that were less than 0.5 acre and old-growth analysis areas less than 1.0 acre were eliminated. This eliminated about 36,000 potential analysis areas and about 6,300 acres from the model.

Management Prescriptions

A prescription is a management practice or group of management practices applied to a specific land area. The planning process involves assignment of the land base to the available prescriptions. This is facilitated by the Woodstock model and is based on forest constraints specific to each forest plan alternative and the objective function.

Prescriptions were developed by the interdisciplinary team to represent the full range of possible management activities and outputs. Since the Tongass models are concerned primarily with timber harvest scheduling, only prescriptions related to timber harvest were modeled. The interdisciplinary team quantified the outputs, costs, and revenues that would occur when these timber prescriptions were applied to a given analysis area. This quantification process produced the output, cost, and revenue coefficients that are used in Woodstock yield and economic tables. The interdisciplinary team, during its development of standards and guidelines for all prescriptions, ensured that the specific management requirements set forth in 36 CFR 219.27 would be met in accomplishing the goals and objectives for the Tongass.

Woodstock prescriptions were developed to allow consideration of a full range of management activities in the analysis areas. A grow only or no-harvest prescription was created for each analysis area as well as several different harvest options. The only criterion used to eliminate timber options from the models was technical feasibility. For example, ground-based/shovel logging was not considered on slopes greater than 35 percent. Consideration of timber prescriptions for any given Analysis Area was not directly limited by economic efficiency, in order to allow them to be chosen in efficient fulfillment of a forest-wide desired condition (CFR 219.14(f)(8)). Available timber options were not eliminated from consideration because they produced a negative PNV or even a lesser PNV than some other timber option. A full range of timber options with varying levels of economic efficiency was available to the model, and the Woodstock model was able to consider the economic efficiency of each prescription during the solution process.

The prescriptions analyzed are briefly described below. Note that all regimes assume natural regen, and that all existing young-growth stands 20 years or less, and all regeneration stands are assumed to have a precommercial thinning to bring the stands to desirable stocking levels.

Grow only or Minimum Level/Maintenance. Applies minimum custodial direction for the timber resource. There is no commercial timber harvest and no production of outputs related to timber harvest. This is the prescription assigned to lands not scheduled for timber harvest

Clearcut. Removal of all merchantable commercial trees within a stand in one operation. This prescription is only available for old-growth stand and existing young-growth stands past the age of precommercial thinning.

Precommercial thinning and clearcut. All young-growth stands 20 years old and younger received a precommercial thinning. Final harvest removes all merchantable commercial trees within a stand in one operation. This prescription is available for young-growth stands 20 years and less, and regenerated stands.

Commercial thinning and clearcut. One commercial thin at age 60, 65, 70, 75, 80 70, 75, or 80. Clearcut at choice of rotation ages.

Precommercial thinning, commercial thinning and clearcut. Young-growth stands 20 years old and less receive a precommercial thinning. One commercial thin at age 60, 65, 70, 75, 80 70, 75, or 80. Clearcut at choice of rotation ages. This prescription is available for young-growth stands 20 years or less and regenerated stands.

Commercial thinning, no subsequent harvest. One commercial thin at age 60 or older; no further entries are allowed. This prescription is available for young-growth stands in certain land allocations, defined for each alternative.

Young Growth Patch Cuts. This regime creates an uneven-age class distribution across space by creating smaller even-aged openings. Up to 35 percent of the stand is harvested in small openings, no larger than 10 acres in size. Openings will naturally regenerate, and precommercial thinning may be scheduled to coincide with a subsequent harvest entry. This prescription is available for young-growth stands in certain land allocations, defined for each alternative.

Old Growth Partial Cut. On first entry into old-growth stands, 75 percent of the standing volume is harvested. The remaining 25 percent of the stand is harvested every 50 years. This prescription is available for old-growth stands in Regulation Class 3.

Minimum Rotation Age

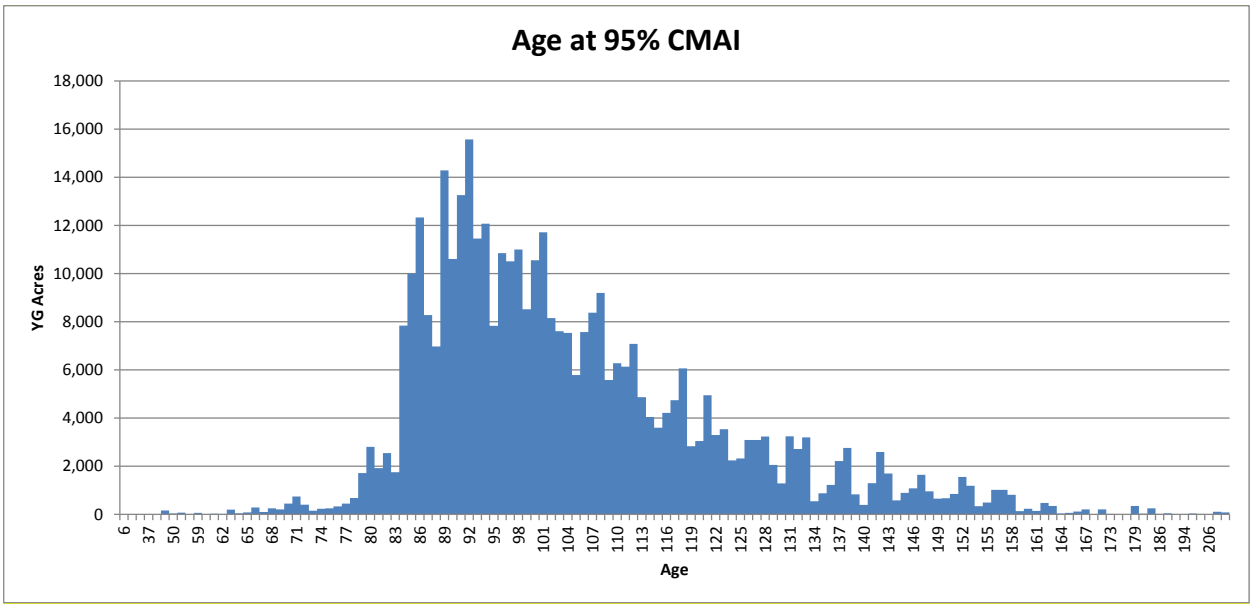
The National Forest Management Act establishes the minimum rotation age for even-aged harvest as the age at which stands have “generally reached culmination of mean annual increment (CMAI)”. The planning regulations define this more specifically as the time that stands reach 95 percent of mean annual increment.

To define this for modeling, young-growth stands were grown forward to project the age at which each stand would reach CMAI. The results indicated that most stands would not reach 95 percent CMAI prior to age 90, and many stands would take considerably longer than that, as shown in Figure B-1 below.

Public Law 113-291 of 2014 made provision for shorter rotations on a limited basis – up to 1,500 acres per year in the first 10-year period, and no more than 50,000 acres in the first 20 years, could be harvested at ages less than 95 percent CMAI. This standard was used as the basis for Alternative 1. However, after 20 years, minimum harvest age was defined by 95 percent CMAI.

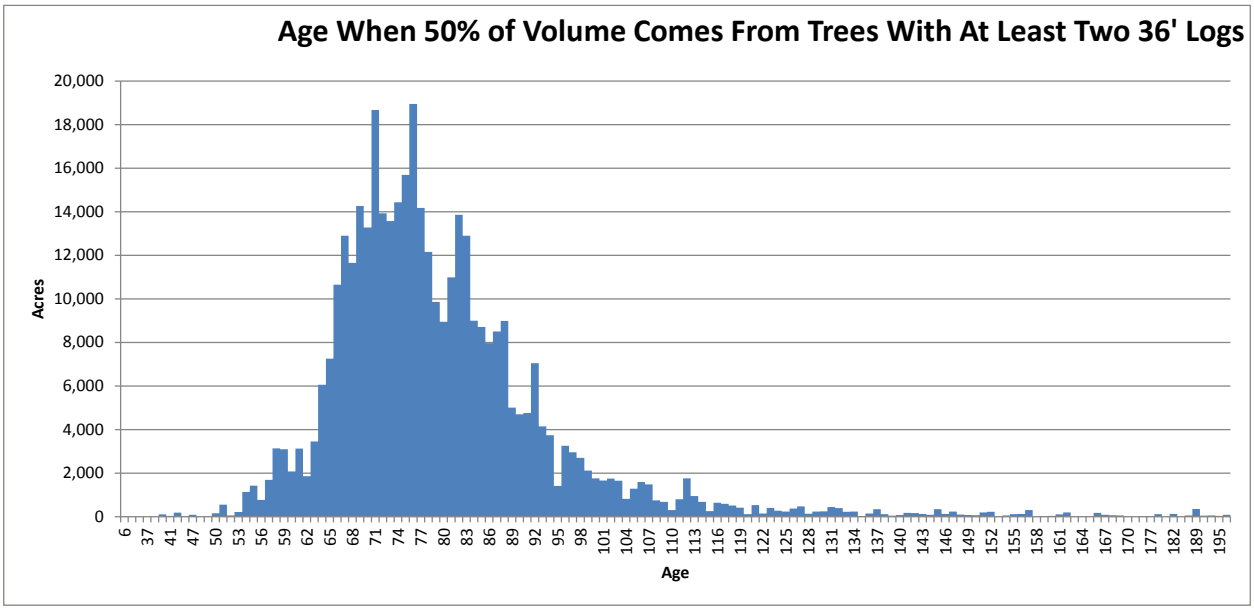
To increase the transition speed to a young-growth harvest program, rotations shorter than 95 percent CMAI were used in Alternatives 2, 3, 4, 5, and 7 (Alternative 7 is the very short-rotation alternative, which was evaluated but not analyzed in detail), and in calculation of the Sustained Yield Limit. Alternative 6 (the State-recommended alternative, which was evaluated but not analyzed in detail) used 95 percent CMAI exclusively.

Figure B-1 Frequency Distribution for Age at 95 Percent CMAI for Young-growth Stands



Minimum rotations less than 95 percent CMAI were based on an analysis of the log products that could be made from young-growth stands. A number of different standards were evaluated. Ultimately, minimum rotation ages for young-growth stands were set at the age at which at least 50 percent of the total volume comes from trees with at least two full 36-ft. logs. Comparing Figure B-2 with Figure B-1 shows that this standard reduces the minimum rotation age for most stands.

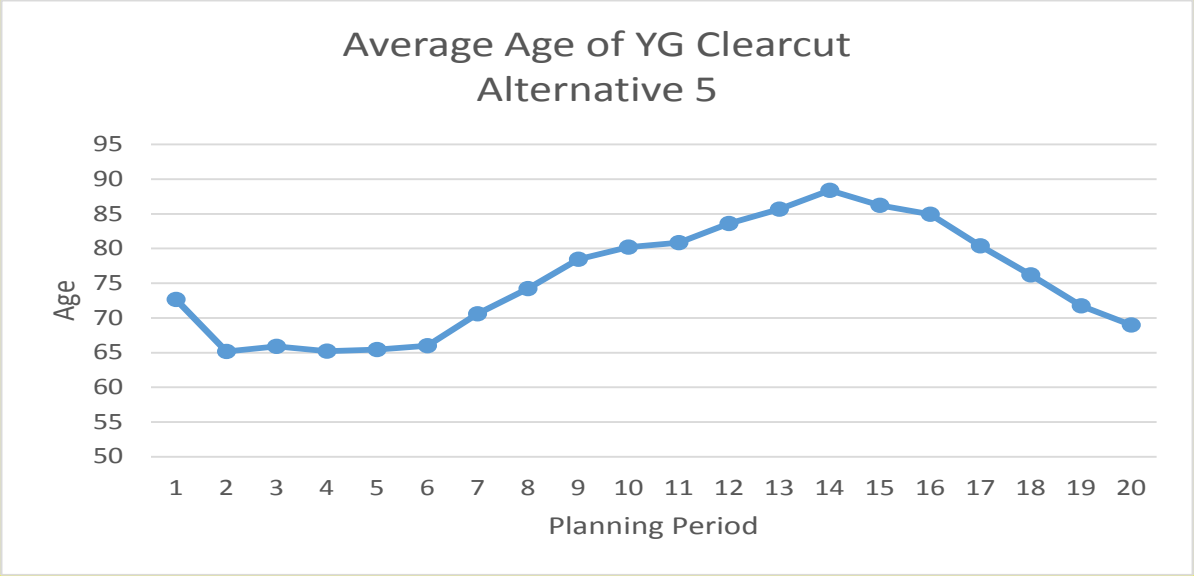
Figure B-2 Frequency Distribution for Age when 50% of Volume Comes from Trees with at least Two 36-ft. Logs



Further analysis indicated that most young-growth stands with a site index of 90 or greater would reach this standard at age 65, and that most stands with site index less than 90 would reach this standard by age 75.

Minimum rotations in the harvest scheduling model were set at 65 for higher site stands (site index 90+) and at 75 for lower site stands (site index less than 90). These minimum rotation ages establish the first time that a young-growth stand could be considered for harvest. Due to the current young-growth age-class distribution, much of the harvest in the early planning periods would come from stands harvested at these minimum rotation ages, as shown in Figure B-3.

Figure B-3 Average Age of Young-growth Clearcuts in the Preferred Alternative 5 by 5-year Planning Period



Activities and Outputs

Management activities create costs and produce outputs, both of which are reflected in the Woodstock model. Each Activity and Output used in the model is described below.

Activity Costs. All costs and values used in the Woodstock are based on the current USFS Region 10 appraisal system. Costs in the model include costs incurred by the timber sale purchaser – logging, haul and presale costs. The Forest Service costs for timber sale preparation and harvest administration are also included in the model, but do not contribute to the Present Net Value objective function. The actual cost figures used in the analyses are available in the planning records.

Coefficient Development and Estimation of Effects. The GIS enables identification and stratification of land into logical groupings. The response of these groups to management activities was determined from a wide variety of existing data. All coefficients and assumptions made in the modeling process have been developed from the following information sources.

Yarding/Logging Costs
Information Source: Calculated using equations from USFS Region 10 timbers sale appraisal spreadsheets.

Occurs With or Varies By: For old growth, varies by volume class, logging operability, geographic zone, productivity group, stand age, and prescription. This cost is incurred according to net sawlogs removed per acre. For young growth, varies by volume per acre, logging operability and harvest method.

Assumptions: These costs include road maintenance relative to logging, profit and risk relative to yarding, landing construction, and yarding. Logging costs increase as operability becomes more difficult. The logging operability classification of the area heavily influences the logging costs due primarily to the different harvest systems required. The size of the logs influences logging costs. Typically, larger logs result in less logging cost per 1,000 board feet. For old growth, volume class and productivity group are used to estimate the average log size and volume per acre for each unit. For young growth, pieces per thousand are used in the young growth logging cost equations to estimate logging costs specific to each stand at each time period.

Logging systems include ground-based/shovel, short-span cable and long-span cable. Helicopter costs will also be determined by three categories of distance (0.5 mile, 1.25 mile, and 2+ mile). Helicopter costs are constant costs independent of volume strata and geographic zone, so they can be applied wherever helicopter logging must be used. Young-growth harvest costs were determined initially from FVS outputs at age 80. They were then adjusted for geographic zone, age, and prescription (i.e., clearcut or thin) using South Islands (POW, where the data was collected) as a reference point. Cost curves from 1996 were used as the basis of this adjustment.

Felling and bucking coefficients
Information Source: Based on most recent USFS Region 10 appraisal spreadsheets.

Occurs With or Varies By: Tracked on a per volume basis (MBF). For old growth, varies by volume class. For young growth, coefficients are based on projected yields for each stand.

Assumptions: Felling and bucking costs were split out separately from logging costs. Old-growth costs varied by Geographic Zone and volume strata.

Outputs (Benefits). The economic benefits associated with timber harvest are based on appraised value. Value is based on tree size, species composition, amount of defect, and assumptions about domestic manufacture and export. Timber benefits are measured as pond log value. Pond log values used in the Woodstock model are the estimates of price a timber buyer would pay for a log at the mill site, less the markup charged by the logger (profit and risk). To get the stumpage value of this log, all

estimated costs that are incurred to get the log to the mill must be subtracted from the pond log value. The resulting stumpage price is assumed to be the price the timber buyer pays for the log (bid price). Bid price represents money to the U.S. Treasury.

Sawtimber (board feet and cubic feet)
Information Source: Timber values were determined using timber appraisal methodologies for Southeast Alaska (FSH 2409.22) as reflected in the most recent USFS Region 10 appraisal spreadsheets.

Merchantable volume of existing old growth timber stands was based on FIA plot analysis by volume strata within each identified Geographic Zone and are the same volumes used in the 2008 Plan.

Yields for existing young-growth timber stands were derived from a recent young growth inventory and a recently updated site index map. In the Woodstock model, each of the approximately 8,100 young-growth stands were grown forward and those unique yield projections were each used in the model. Stands 20 years old and younger were assumed to have a precommercial thin to achieve desirable stocking levels.

Yields for future regenerated stands were based on a subset of the young growth yields. All future stands are assumed to have desirable stocking due to precommercial thinning.

Occurs With or Varies By: At harvest, the old-growth volume of merchantable timber produced generates a revenue per mbf that varies by Geographic Zone and volume class. Geographic zone affects this revenue due to differences in species composition and wood quality. Young growth harvest revenue is based on the species and size class of the harvested logs.

Assumptions: For existing old-growth stands, piece size and species composition is determined from a tree-by-tree analysis of the FIA plot summary data. For young growth and regenerated stands, piece size and species composition is based on a tree-by-tree analysis of the FPS model outputs. It is assumed that existing old-growth volumes are constant (i.e., through time, growth equals mortality). Young- growth (regenerated) stands grow at a rate determined by the FPS model. Pond values are based on the assumption that for species that are exported, half of the volume will be exported, and half will be processed by domestic manufacturers.

Woodstock Constraints

Constraints in a linear programming model are the rules that must be followed when determining an optimal problem solution. Without constraints, the solution of a Woodstock model may represent a management strategy that is impractical, inconsistent with the forest plan, or in conflict with Forest Service policy. Thus, constraints are included in Woodstock models to ensure that their results are useful and meaningful.

There are two categories of constraints within a Woodstock linear programming matrix: implicit and explicit. Implicit constraints are common to all Woodstock models. For example, all acres in the model must be allocated to some prescription (even if it is the “no management” prescription), or the number of acres assigned to each prescription must not be negative. These types of constraints are exercises in logic and need not be discussed further.

Explicit constraints are those constraints added to Woodstock models by planners. These constraints come in many forms and are applied to mimic regulations and laws such as NFMA, standards and guidelines set forth in the forest plan, and on-the-ground operating conditions. An example is the non-declining yield constraint. Proven ability to maintain a constant flow (non-declining yield) of harvested timber volume in perpetuity is Forest Service policy. A constraint is added to the Woodstock data set that forces all timber harvest volumes to be at least as great as the previous decade's harvest volume (see below for further discussion). Another example may be a constraint that forces a certain area to be

managed specifically for wildlife habitat. There are many explicit constraints in the Tongass models. They vary by land attributes, geographic area, and by management alternative. The explicit constraints used in the Woodstock models fall into two categories: timber policy constraints and operational constraints. A detailed discussion of the intent of these constraints follows. They are summarized in Table B-2 for comparison of their application across the alternatives.

Timber policy constraints. These constraints are included in the Woodstock models to represent legal or policy requirements of national forest timber management. The primary requirements regarding timber management incorporated into Tongass Woodstock models are:

Non-declining Yield. The Tongass models have a constraint that ensures harvest volume (in board feet) will not decline in any period over the 100-year planning horizon per national policy. Harvest volumes may increase, but all subsequent harvests must be at least as much as the previous decade's harvest.

Sustained Yield. The harvest in any decade of the planning horizon must not exceed the Long-Term Sustained Yield that can be maintained on the forest. Long-term sustained yield is measured in cubic feet. It is calculated as the average yearly volume yielded from a chosen management action, summed across all management actions for all stands chosen by the model. For instance, if a management action yields 50 cubic feet every 100 years, the Long-Term Sustained Yield for that management action is 0.5 cubic feet per year.

Minimum harvest age. The age at which a managed stand is harvested is called the rotation age. Agency policy has been that rotation age can be no earlier than the age at which 95% of culmination of mean annual increment (CMAI) occurs. As discussed above, because of this transition to young-growth management, most alternatives in this plan amendment allow harvest at ages younger than 95% CMAI (based on legislative and NFMA exceptions).

Constraints Common Across All Alternatives. There are four constraints common to all seven alternatives. They are: (1) Non-declining yield, (2) Harvest during the first three periods – can only come from Craig, Thorne Bay, Ketchikan, Petersburg, and Wrangell Districts; after that, all nine timber districts are available become available, (3) Normal operability constraints, and (4) Old growth high volume strata constraints.

Compatibility Matrices Specific to Each Alternative. The Tables below show which management regimes are compatible with each land use allocation, under each alternative. These "compatibility matrices" were used to build the land allocation constraints into the Woodstock models.

Table B-2.0
Key for Codes Found in Tables B-2.1-7

Code	Description
NH	No Harvest
CC	Clearcut
GS	Group Selection and Patch Cut
VR	Variable Retention
CT	Commercial Thin
Par	Partial Harvest
YG	Young Growth
OG	Old Growth
x1	x1 = Phase 1 only
x2	Remove 33% of volume
x3	Only CC harvest in Period 1-3, then CT but no CC
x4	Patch cutting in Moderate, clearcut in Low
x5	Minimum age 60/70
x6	Where also OG and RMA, minimum age 65/75

Table B-2.1
Compatibility Matrix Alternative 1

	YG				OG		
	NH	CC	CT CC	CT	NH	CC	Par
Roadless	x	-	-	-	x	-	-
Phase I, II and III	x	x	-		x	x	x
Roaded Roadless	x	-	-	-	x	-	-
Beach Buffer	x	-	-	-	x	-	-
Karst - High	x	-	-	-	x	-	-
Karst - Moderate & Low	x	x	-		x	x	x
LUD - Non Development	x	-	-	-	x	-	-
RMA outside TTRA Buffer	x	-	-	-	x	-	-
Steep Slope, MMI 4	x	x	-	-	x	-	-
LUD - Modified Landscape	x	x	-	-	x	x	x
LUD - Scenic Viewshed	x	x	-	-	x	x	x
LUD - Timber Production	x	x	-	-	x	x	X

*Relax CMAI on 50,000 acres in first 20 yrs (1st decade 15,000 ac, no more than 1500 ac per year)
*FP Scenery Standards apply (Reg class constraints by VCU)
*YG use 2 log trigger
*If YG+OG > 46, then OG volume = 5, else OG+YG = 46
*Total harvest during transition <= 46

Table B-2.2
Compatibility Matrix Alternative 2

	YG				OG		
	NH	CC	CT CC	CT	NH	CC	Par
Roadless	x	-	-	-	x	-	-
Phase I, II and III	x	x	-		x	x	x
Roaded Roadless	x	x	-	-	x	x	x
Beach Buffer	x	x3	-	x	x	-	-
Karst - High	x	-	-	x	x	-	-
Karst - Moderate & Low	x	x	-		x	x	x
LUD - Non Development	x	x	-	-	x	-	-
RMA outside TTRA Buffer	x	-	-	x2	x	-	-
Steep Slope, MMI 4	x	x	-	-	x	-	-
LUD - Modified Landscape	x	x	-	-	x	x	x
LUD - Scenic Viewshed	x	x	-	-	x	x	x
LUD - Timber Production	x	x	-	-	x	x	X

*Relax CMAI on 50,000 acres in first 20 yrs (1st decade 15,000 ac, no more than 1500 ac per year)
*FP Scenery Standards apply (Reg class constraints by VCU)
*YG use 2 log trigger
*If YG+OG > 46, then OG volume = 5, else OG+YG = 46
*Total harvest during transition <= 46

Table B-2.3
Compatibility Matrix Alternative 3

	YG				OG		
	NH	CC	CT CC	CT	NH	CC	Par
Roadless	x	x	-	-	x	x	x
Phase I, II and III	x	x	-		x	x1	x1
Roaded Roadless	x	x	-	-	x	x	x
Beach Buffer	x	-	-	x	x	-	-
Karst - High	x	-	-	x	x	-	-
Karst - Moderate & Low	x	x	-		x	x	x
LUD - Non Development	x	x	-	-	x	-	-
RMA outside TTRA Buffer	x	-	-	-	x	-	-
Steep Slope, MMI 4	x	x	-	-	x	-	-
LUD - Modified Landscape	x	x	-	-	x	x	x
LUD - Scenic Viewshed	x	x	-	-	x	x	x
LUD - Timber Production	x	x	-	-	x	x	X

*Relax CMAI on 50,000 acres in first 20 yrs (1st decade 15,000 ac, no more than 1500 ac per year)
*FP Scenery Standards apply (Reg class constraints by VCU)
*YG use 2 log trigger
*If YG+OG > 46, then OG volume = 5, else OG+YG = 46
*Total harvest during transition <= 46

Table B-2.4
Compatibility Matrix Alternative 4

	YG				OG		
	NH	CC	CT CC	CT	NH	CC	Par
Roadless	x	-	-	-	x	-	-
Phase I, II and III	x	x1	-	-	x	x1	x1
Roaded Roadless	x	-	-	-	x	-	-
Beach Buffer	x	-	-	x	x	-	-
Karst - High	x	-	-	x	x	-	-
Karst - Moderate & Low	x	x	-		x	x	x
LUD - Non Development	x	-	-	-	x	-	-
RMA outside TTRA Buffer	x	-	-	-	x	-	-
Steep Slope, MMI 4	x	x	-	-	x	-	-
LUD - Modified Landscape	x	x	-	-	x	x	x
LUD - Scenic Viewshed	x	x	-	-	x	x	x
LUD - Timber Production	x	x	-	-	x	x	X

*Relax CMAI on all acres and time periods
*FP Scenery Standards apply (Reg class constraints by VCU)
*YG use 2 log trigger
*If YG+OG > 46, then OG volume = 5, else OG+YG = 46
*Total harvest during transition <= 46

Table B-2.5
Compatibility Matrix Alternative 5

	YG						OG		
	NH	CC	CT CC	GS	VR	CT	NH	CC	Par
Roadless	x	-	-	-	-	-	x	-	-
Phase I, II and III	x	x	-	-	-	-	x	x	x
Roaded Roadless	x	-	-	-	-	-	x	-	-
Beach Buffer	x	-	-	-	x6	x	x	-	-
Karst - High	x	-	-	-	-	-	x	-	
Karst - Moderate & Low	x	x4	-			-	x	x	x
LUD - Non Development	x	-	-	x5	-	-	x	-	-
RMA outside TTRA Buffer	x	-	-	x5	-	x	x	-	-
Steep Slope, MMI 4	x	-	-	-	-	-	x	-	-
LUD - Modified Landscape	x	x	-	-	x6	-	x	x	x
LUD - Scenic Viewshed	x	x	-	-	x6	-	x	x	x
LUD - Timber Production	x	x	-	-	-	-	x	x	X

*Relax CMAI on all acres and time periods
*FP Scenery Standards apply (Reg class constraints by VCU)
*YG use 2 log trigger
*If YG+OG > 46, then OG volume = 5, else OG+YG = 46
*Total harvest during transition <= 46

Table B-2.6
Compatibility Matrix Alternative 6
(State of Alaska alternative – modeled, but not analyzed in detail)

	YG				OG		
	NH	CC	CT CC	CT	NH	CC	Par
Roadless	x	x	-	-	-	x	x
Phase I, II and III	x	x	-	-	-	x	x
Roaded Roadless	x	x	-	-	-	x	x
Beach Buffer	x	-	-	-	-	-	-
Karst - High	x	-	-	x	x	-	-
Karst - Moderate & Low	x	x	-		x	x	x
LUD - Non Development	x	-	-	-	x	-	-
RMA outside TTRA Buffer	x	-	-	-	x	-	-
Steep Slope, MMI 4	x	-	-	-	x	-	-
LUD - Modified Landscape	x	x	-	-	x	x	x
LUD - Scenic Viewshed	x	x	-	-	x	x	x
LUD - Timber Production	x	x	-	-	x	x	X

*95% CMAI on all acres and time periods
*No FP Scenery Standards in this alternative
*Total acreage in even-aged stands less than 150 years would be limited to 33% of the forested acres within a VCU.
*If YG+OG > 46, then OG volume = 5, else OG+YG = 46
*Total harvest during transition <= 46

Table B-2.7
Compatibility Matrix Alternative 7
(Conservation group alternative – two options modeled, but not analyzed in detail)

	YG				OG		
	NH	CC	CT CC	CT	NH	CC	Par
Roadless	x	-	-	-	x	-	-
Phase I, II and III	x	x	x		x	x	x
Roaded Roadless	x	-	-	-	x	-	-
Beach Buffer	x	-	-	-	x	-	-
Karst - High	x	-	-	-	x	-	-
Karst - Moderate & Low	x	-	-		x	x	x
LUD - Non Development	x	-	-	-	x	-	-
RMA outside TTRA Buffer	x	-	-	-	x	-	-
Steep Slope, MMI 4	x	-	-	-	x	-	-
LUD - Modified Landscape	x	x	x	-	x	x	x
LUD - Scenic Viewshed	x	x	x	-	x	x	x
LUD - Timber Production	x	x	x	-	x	x	X

*Relax CMAI on all acres and time periods
*FP Scenery Standards apply (Reg class constraints by VCU)
*Short log min CC age = 55
*Long log min CC age = 65/75
*Transition ends @ 5 years-OG harvest levels out at 3.5 MMbf/year
*If YG+OG > 46, then OG volume = 5, else OG+YG = 46
*Total harvest during transition = 35

Model Implementation Reduction Factor Constraints (MIRF). These constraints are designed to accommodate for unmapped unsuitable lands that were missed during the suitability determination. It is assumed that when harvest activities occur, a certain percentage of the assumed suitable land will be off-limits for management due to several economic or ecological considerations. These constraints are applied to each old-growth volume strata of each of the six operability harvest systems as well as to young-growth stands. The constraint is implemented by forcing the model to never harvest a certain percentage of the acres in the model. The effect is to control the maximum amount of acres from the suitable land base that are actually harvested. See below for a discussion of how MIRF factors were determined.

Dispersion and Adjacency Constraints. To meet visual quality and Regulation Class objectives, dispersion and adjacency constraints were incorporated into the models. “Dispersion” refers to spreading harvests across the landscape rather than focusing all activities in a concentrated area. The dispersion limits are taken from proxies developed by Tongass landscape architects for each LUD. These visual guidelines estimate how much of a viewshed can be "disturbed" at any one time and still meet the adopted scenic integrity objectives of the area. They also specify length of time before harvest of adjacent units is permissible and the maximum size of these harvest units. Table B-7 (below) shows the constraints that were used for each Regulation Class. The “Visual Disturbance” factors were used in the constraints section of the model and the “Adjacency” definitions were defined in the outputs section of the model. Together, these two definitions (as well as treatment options available to each regulation class) distinguish the regulation classes in the model. Detailed information about these constraints is found in the “Regulation Class” section of this appendix (below).

Woodstock Solution Process

The following sections describe some of the steps involved in solving the Woodstock models. Following that is a brief discussion of how the Tongass evaluated economic efficiency of the alternatives.

Objective Functions

The objective function of a linear programming model allows the model to determine the "best" set of management actions that meet the constraints. It is generally expressed as a "minimize" or "maximize" function. The LP solution software finds the largest (or smallest) value possible of the objective function within the boundaries of the model constraints. Linear programming principles guarantee that the solution is optimal; that is, the best answer possible. Different objective functions were used to explore the Tongass management problem. While the "maximize present net value" objective function was used for the final results, the others were used at intermediate steps in the analysis process. Some of the objective functions used in the modeling process include:

Maximize Net Present Value. Present Net Value (PNV) is defined as the benefits less the costs of a management prescription, discounted at 4 percent annually to the present day, summed over all management prescriptions of all Analysis Areas. Because the model is formulated in 5-year time periods, discounting is done from the middle of each period. This is the objective function that was used for all final model runs presented in this FEIS. This ensures that the final harvest schedule is the most economically efficient approach to meeting the constraints with the available stands.

Maximize Discounted Timber Volume. Timber volume is tracked for each management action of each Analysis Area in each period. Each volume is discounted to the present and the total amount is maximized. The Woodstock model was used to determine how quickly the Tongass could transition to a sustainable timber sale program comprised primarily of young-growth harvest, and how high the young-growth harvest could be, given the land allocation and other management constraints. Maximizing discounted volume ensured that the model had the incentive to get as much young-growth volume as possible, early in the harvest schedule. The non-declining yield constraint ensure that the young-growth harvest was sustainable, and allowed the harvest to increase over time as the young-growth age class distribution was regulated. The discount rate used for this calculation was 16 percent. This objective function was used only in the initial run.

The solution process for each alternative consisted of making a set of Woodstock model runs designed to find the most cost efficient way to transition to a young-growth harvest program as rapidly as possible. The general procedure was as follows:

> Initial Run - Determine the highest level of sustainable young-growth harvest, given the land allocation constraints. This model includes only the young-growth acres. Management regimes are limited to those compatible with the land allocation. Harvest is limited to non-declining flow – harvest may increase from one period to the next, but may not decrease. The objective function maximizes discounted harvest volume. This run produces the highest level harvest in the early periods that is sustainable through time.
>
> First Old-growth Run – the old-growth acres are added to the model. Young-growth harvest is constrained to meet the level established in the initial run through the transition period. Old-growth harvest is constrained such that total harvest meets the target volume during the transition period (46 MMbf per year, in most alternatives). After the transition period, old-growth harvest is established at 5 MMbf per year. The maximize PNV objective function was used on this an all subsequent runs.
>
> Intermediate Old-growth Runs – Constraints affecting the selection old-growth harvest are added sequentially to ensure that the model results are in the expected range. These constraints include the old-growth operability constraints, the constraints limiting the harvest of RegClass 3 old-growth acres, and constraints limiting the harvest of high volume old-growth stands.
>
> Final Run – All constraints are included and the model is run to maximize PNV. This ensures that the objectives and constraints are met in a cost efficient manner.

At each step, the Woodstock model results are evaluated to ensure that the solutions are consistent with the design of each Alternative.

Iterative Process

The Woodstock model was used to test the assumptions and problem formulation strategies used in this analysis. The final solution for each alternative is often the result of several runs that were used to test to test the solution space given the land allocation constraints, and to observe the impact that the implementation constraints had on the solution. Early on, model runs were made to validate the model and compare it to previous models. A number of runs were made to test the solution space, especially around the question of potential young-growth harvest levels under different potential harvest policies.

Present Net Value

Economic benefits from the Woodstock model were calculated as Present Net Value, or PNV, of the scheduled timber management activities. This calculation was done by the Woodstock model using pond log values and costs to the logger. The formula used to calculate the PNV of each potential management prescription is:

$$PNV = [PLV - LC]/(1 + d)^t$$

where:

PLV = pond log value (adjusted to exclude logger profit and risk)
LC = Logging costs (operability, haul, LTF, camp/commute, felling and bucking, road building)
t = time (year) of harvest into the future
d = discount rate (4% annually)

The dollar values of outputs used to calculate PNV in the Woodstock model are pond log values measured at mill sites less the profit and risk to the seller. The costs weighed against these values included all of the expenses incurred from removing the timber from the site to the mill (including logging costs, haul costs, LTF costs, road building costs, as described above in the *Activities and Output* subsection). This is done to account for the variability in stumpage values that occur over such a large land area that is the Tongass National Forest. Stumpage value is the value of the timber at the site and is considered receipts to the federal government for a timber sale. In other words, it is what a purchaser will pay for the timber after considering all of the expenses (LC in the equation above) that are incurred in removing it to the mill. Stumpage, while not explicitly calculated before it is entered into the Woodstock model, it is an inherent part of the above equation [PLV – LC] that is calculated by Woodstock for all potential management prescriptions.

See the above section on Activities and Outputs for more detailed information on each of the costs and timber values used in the Woodstock model.

Supplemental Information on Other Model Assumptions

Stage II Suitability Analysis

Each acre classified as suitable for timber harvest was analyzed to determine the costs and benefits for a range or management intensities (36 CFR 219.14(b)). For the purpose of this analysis, the planning area was stratified into categories of land with similar costs and returns according to the Analysis Area Identifiers described above. The stratification also took into account those factors that influence costs and returns such as physical and biological conditions of the site (affecting logging system) and transportation requirements (by VCU).

Stage II analysis is used to identify management intensities of timber production for each category of land that results in the largest amount of discounted net revenues. Stage II analysis provides insight into the overall economic condition of the suitable land base and what types of land are most cost efficient for management. The costs and benefits used for this analysis are described above and include pond log

value, the cost of logging, removing, and transporting the timber to the mill. This analysis does not account for the utility volume costs or revenues, as the current market conditions do not favor its removal.

Stage II analysis was conducted for all applicable management intensities: Intensive even-aged management with thinning regimes to very small clearcuts and group selection/patch cut prescriptions (regulation class 3 areas).

The Regulation Class Process

To recognize the varying intensities of timber harvests that may occur on the landscape, the regulation class concept was developed. Regulation Class is a methodology developed to distill the unique combinations of Land Use Designation (LUD), Distance Zone (DZ), Scenic Integrity Objective (SIO), and Visual Absorption Capacity (VAC) into four management categories, or Regulation Classes. These classes group lands that allow similar allowable harvest unit size, visual disturbance, and re-entry times (adjacency). Regulation Classes are numbered 0 to 3, with 0 being ineligible for management. Most of the following discussion is focused on Regulation Classes 1-3.

Land Use Designation (LUD). For each alternative, a unique assignment and map of Land Use Designations was developed. Every Land Use Designation, or LUD, delineates a unique set of standards and guidelines that apply to that area. For each alternative, up to 19 LUDs were recognized, but only a subset of these were allowed to produce commercial timber that contributed to the PTSQ. Scenic Viewshed, Modified Landscape, and Timber Production LUDs were available in all alternatives and represent the primary LUDs for timber management. These three LUDs were evaluated in the Regulation Class process. In addition, several alternatives allow young-growth harvest in specific natural setting LUDs, such as Old-Growth Habitat and Semi-Remote Recreation. See the supplemental alternative LUD maps, the alternative descriptions in Chapter 2 of the FEIS, and Chapter 3 of the Forest Plan for more specific information on LUDs.

Distance Zone (DZ). The amount of allowable timber harvesting also is affected by distance zone (DZ). Distance zone is the proximity of an area to a view-point. Distance zone varies from Foreground (within a 0.25 mile), Middle Ground, Background, to Seldom Seen, which is completely out-of-view from selected viewing points. Again, available treatment intensity is usually greater on lands with more hidden Distance Zones.

Scenic Integrity Objectives (SIO). Scenic Integrity Objectives are a function of LUD and Distance Zone and describe the desired quality of the scenery to be maintained in each classification. The categories include “High,” “Moderate,” “Low,” and “Very Low” objectives. Further description of SIOs is found in the “Scenery” section of Chapter 4 in the Forest Plan. SIOs for each of the LUD/Distance Zone combinations in the development LUDs are shown in Table B-3.

Visual Absorption Capability (VAC). The VAC is a measure of an area's ability to "absorb" (make visually less noticeable) ground disturbing activities (i.e., timber harvesting). VAC is simplified to three categories: Low, Interim, and High. VAC is used to define the intensity of management treatments that can be used to maintain each SIO. Generally, areas with greater VAC can sustain a more intensive treatment while still maintaining the desired SIO. Table B-4 shows the management unit size allowed for each SIO/VAC combination.

Tongass landscape architects developed some general timber harvesting guidelines, or proxies, for various VACs, SIOs, and LUDs. Although the exact harvest intensity an area receives is determined during the timber sale layout stages, estimates of allowable disturbance were needed in order to facilitate modeling. Each LUD has a series of adopted SIO and VAC objectives. Associated with these objectives are the estimated allowable disturbance factors. The proxies for each LUD and SIO/VAC setting were grouped by similar harvest method and unit size, cumulative visual disturbance, and height to adjacent stand criteria. Grouping the proxies of similar standards resulted in the creation of four distinct categories. These groups became the four regulation classes used in Woodstock modeling. These groups range from no harvest allowed to large clearcutting with minimal visual concerns. The GIS is then used to provide Woodstock with the regulation class allocations by alternative for each Analysis Area. Table B-5 summarizes the approximate disturbance factors by LUD, Distance Zone, SIO, and VAC.

Table B-3
SIO for Distance Zone/LUD from Scenery Standards and Guidelines for Development LUDs

LUD	Foreground	Middle Ground	Background	Not Seen
Scenic Viewshed	Retention	Partial Retention	Partial Retention	Max Modification
Modified Landscape	Partial Retention	Modification	Modification	Max Modification
Timber Production	Modification	Max Modification	Max Modification	Max Modification

Table B-4
Maximum Unit Size based on Visual Absorption Capability

SIO	Low VAC	Interm. VAC	High VAC
High	< 2	5-15	15-30
Moderate	5-10	15-40	40-60
Low	15-40	40-60	80-100
Very Low	50-75	80-100	80-100

The percentages in Table B-5 are rough estimates intended to depict the possible level of disturbance one may encounter when viewing these areas. For modeling purposes, these visual disturbance zones were aggregated into groups with similar standards and economic response (e.g., logging costs). Because the percent of visual disturbance includes all visible terrain, tests had to be conducted to "recalculate" disturbance thresholds since only suitable lands are being modeled. These tests involved a series of iterative mapping exercises where varying levels disturbance factors were applied to the separate groups. The feasibility of the harvest level was then compared to the standards and guidelines and reviewed by Tongass National Forest landscape architects. This work was conducted under the following assumptions:

1. The items in the database (e.g., distance zone, visual absorption capability) were correct,
2. The standards and guidelines are modeled to their limits, and
3. The "viewshed" was a large area (e.g., as viewed from a boat).

This work indicated a need to further review the scenery components of the database but in general the process worked well in terms of modeling the intent of the standards and guidelines. This work resulted in three distinct regulation classes that permit timber harvest activities. The final allocation of regulation classes to the various disturbance zones is shown in Table B-6.

Table B-5
Percent Allowable Visual Disturbance

Land Use Designation	Distance Zone	SIO	Low VAC	Interm. VAC	High VAC
Scenic Viewshed	Foreground	H	8	10	10
	Mid. Ground	M	8	15	20
	Background	M	20	20	20
	Not Seen	VL	20	20	20
Modified Landscape	Foreground	M	8	15	20
	Mid. Ground	L	15	20	25
	Background	L	25	25	25
	Not Seen	VL	25	25	25
Timber Production	Foreground	L	15	20	25
	Mid. Ground	VL	50	50	50
	Background	VL	50	50	50
	Not Seen	VL	50	50	50

[1]H = High, M = Moderate, L = Low, VL = Very Low

Table B-6
Regulation Class Allocation

Land Use Designation	Distance Zone	SIO[1]	Low VAC	Intermediate VAC	High VAC
Scenic Viewshed	Foreground	H	3	3	2
	Mid. Ground	M	3	3	2
	Background	M	3	2	1
	Not Seen	VL	1	1	1
Modified Landscape	Foreground	M	3	3	1
	Mid. Ground	L	2	2	1
	Background	L	2	1	1
	Not Seen	VL	1	1	1
Timber Production	Foreground	L	2	2	1
	Mid. Ground	VL	2	1	1
	Background	VL	1	1	1
	Not Seen	VL	1	1	1

[1]H = High, M = Moderate, L = Low, VL = Very Low

There are two main components of scenery constraints applied to the Regulation Classes in each VCU: the total visual disturbance and adjacency considerations. Total visual disturbance is the percent of land within a viewshed (VCU) that is classified as disturbed (Table B-7). Adjacency refers to the amount of time required before a harvest unit can be placed immediately next to an existing harvest unit (often referred to as the “green-up” period). These constraints are shown in Table B-7.

There are several important things to remember regarding the above table:

1. Disturbance percent is applied to suitable lands only, not the entire viewshed.
2. These values are entered into the models as constraints for each VCU.
3. The disturbance and adjacency factors for Regulation Class 3 are based on the use of small patch cutting (less than 2 acres). Optimally, disturbance and adjacency would not be an issue with carefully planned uneven-aged management (i.e., partial stand removal).

Variation by Alternative. Because LUD is one factor in determining Regulation Class, the breakdown of each of the seven alternatives into regulation class was recalculated for each alternative. A GIS map of Regulation Class was developed and used to intersect with the other layers used in Analysis Area development. Regulation Class was then used as an attribute to help define Analysis Areas.

Table B-7
Generalized Visual Constraints
Regulation Class Visual Disturbance Adjacency

Regulation Class	Visual Disturbance	Adjacency
1	40%	20 Years
2	30%	35 Years
3	20%	50 Years

Model Implementation Reduction Factors (MIRF)

To reiterate what was stated in the "Constraints" section (above), the use of MIRF is designed to accommodate for unmapped unsuitable lands that cannot be directly eliminated from the suitable land base but should be. It is known that when harvest activities occur, a certain percentage of the assumed suitable land will be ineligible for management (unsuitable) due to a number of physical, biological, or economic considerations. However, reasonable assumptions can be made to estimate the average amounts of these elements on the ground. Their effect on actual suitable land can be incorporated into the Woodstock model as constraints. Constraints are applied to each old-growth volume strata of each of the six operability harvest systems as well as to young-growth stands. The constraints are implemented by forcing the model to never harvest a certain percentage of the acres in the model. The effect is to control the maximum amount of acres from the "pre-MIRF" suitable land base that are actually harvested. A discussion of these elements and their estimated amounts follows.

MIRF Elements. Each of the nine MIRF subfactors used in the 1997 FEIS (Riparian Habitat was previously divided into two subfactors so there were 10 identified in 1997) was re-evaluated for the 2008 FEIS. This review was conducted again for the current Forest Plan Amendment EIS and it was decided to leave the subfactors alone, as defined for the 2008 FEIS. A detailed description of the derivation of MIRF is presented in Appendix B of USDA Forest Service (2008). Each of the subfactors and their values are described in the following paragraphs.

Land Selections – This subfactor is the reduction in suitable lands due to the conveyance of selected lands to the State of Alaska and Native interests. In 2008 the value of this subfactor was calculated as 1% for old growth and young growth. Public Law 113-291 significantly affects the number of acres to be conveyed in the future; however, because the factor is already small and because it is believed that the percentage of suitable in remaining acres of potential conveyance lands could be larger than previously assumed, it was left alone.

TTRA Stream Buffers – This subfactor estimates the reduction in the suitable land base due to unmapped Class I and II stream buffers. It is assumed that the percentage reduction due to this subfactor is 2% for old growth and 1% for young growth.

Non-Commercial Forest – This subfactor estimates the reduction in the suitable land base due to volume class mapping errors. It is associated with the low-volume stratum and is defined as the net percent change in suitable acres due to low-volume productive old growth (POG) being mapped as non-commercial (unsuitable) and non-commercial forest being mapped as low-volume POG. It is estimated as a 10% reduction in suitable for old growth and no reduction for young growth.

Slope/Soil Hazard – This subfactor estimates the reduction in the suitable land base due to unmapped steep slopes. It represents the additional acreage of steep slopes identified during project implementation that is not already mapped, divided by the mapped suitable acres. This subfactor varies according to administrative area: the Chatham MIRF for this subfactor is estimated at 26% for old growth

and 10% for young growth and the Ketchikan and Stikine MIRFs are estimated at 1% for both old growth and young growth.

- Cost Efficiency – This subfactor excludes the stands with the lowest economic potential from the suitable land base. It varies with operability class and volume stratum and the reduction is estimated at 25% for Difficult/Low Volume and Isolated/Medium Volume and 50% for Isolated/Low Volume. For young growth, no reduction is assumed.

Riparian Habitat (Class III streams) – This subfactor estimates the reduction in the suitable land base due to unmapped Class III stream buffers. It is estimated at 8% for old growth and 4% for young growth.

Karst/Caves – This subfactor estimates the reduction in the suitable land base due to a change in karst classification from low – moderate to high vulnerability. This subfactor varies according to administrative area: the Ketchikan, Stikine, and Chatham reductions are estimated at 6%, 0%, and 1% for old growth and 3%, 0%, and 1% for young growth, respectively.

- Remaining Standards and Guidelines – This subfactor estimates the reduction in the suitable land base due to unmapped eagle/osprey nests, goshawk nests, murrelet nests, wolf dens, goat habitat, and other factors. It is estimated at a 1% reduction for both old growth and young growth.

Overall Results. The sum of these subfactors produces the overall MIRF for each category (Administrative Area, volume strata, operability class). MIRFs were applied identically for all alternatives. Specific calculated MIRF values are in the planning record. The range of MIRFs (varying with operability class) for the different volume strata and Administrative Areas are as follows:

	Low Volume	Medium Volume	High Volume
Chatham	49% – 99%	39% – 64%	39%
Stikine	23% – 73%	13% – 38%	13%
Ketchikan	29% – 79%	19% – 44%	19%

Estimation of Past and Future Harvest and Road Construction for Effects Analysis

The quantification of the direct, indirect, and cumulative effects of the alternatives on fish, wildlife, plants, and other resources was based heavily on the estimation of past and future harvest of old growth and young growth and the amount of road construction. These tasks were conducted for both National Forest System (NFS) and non-NFS lands. This section describes the process followed and the major assumptions.

Estimation of Past and Future Harvest

The estimation of the direct, indirect, and cumulative effects of the alternatives on POG habitats and the fish, wildlife, and plants that use these habitats required three major steps. First, it was necessary to assemble the inventory of existing vegetation on both NFS and non-NFS lands. The second step was the estimation of the original POG (existing in 1954, prior to large-scale commercial timber harvest) on NFS and non-NFS lands and the classification of this original POG into POG types for the purpose of evaluating the level of disproportionate past harvest. The third step was the estimation of future harvest and the amount of POG in various POG categories that would be remaining after future harvest on NFS lands under each alternative, and for all lands combined, including factors for future harvest on non-NFS lands.

Vegetation Inventory

For NFS lands, the existing vegetation information from the Tongass Geographic Information System (GIS) library was used. Specifically, the Size Density Model (SDM) (see Affected Environment in the *Biodiversity* section) was used for the classification of existing vegetation on the Tongass. Using this

model, POG is defined by seven old-growth types: SD67, SD5N, SD5S, SD5H, SD4N, SD4S, and SD4H. Young growth is defined by six types, depending on the approximate age and origin of the stand; natural young growth (e.g., young growth originating from blowdown) is divided into three types (S1, S2, and S3) and young growth that originated from timber harvest is classified into three types (HS1, HS2, and HS3). It is noted that the stands covered by these young-growth categories are not all even-age stands. Young-growth under even-aged management was identified separately using harvest activity information.

For non-NFS lands, a number of sources of information were used to produce the most updated and accurate mapping available for non-NFS lands in Southeast Alaska. These sources included:

- Sealaska Regional Corporation provided updated GIS layers for vegetation and harvest on their lands throughout Southeast Alaska; these layers were used for mapping all Sealaska lands.
- The State of Alaska provided GIS layers for harvesting on state lands in Southeast Alaska. These layers were used for most state lands.
- Audubon Alaska and The Nature Conservancy completed a conservation assessment for Southeast Alaska (Albert and Schoen 2007) that included the development of a reasonably accurate vegetation map of the entire region based on Tongass GIS vegetation data (SDM mapping), augmented with timber inventory data from Haines State Forest and with classified Landsat Multi-spectral Scanner (MSS) imagery from the Interim Landcover Mapping Program of the U.S. Geological Survey, and 1997 aerial photography. This mapping was used for most of the remainder of Southeast Alaska.
- Forest Service orthophotography and aerial photography was interpreted in some areas to fill in gaps in the above layers.
- The Working Forest Group provided more recent southeast Alaska harvest mapping.

Based on the above information, a Catalogue of Past Harvest for all of Southeast Alaska was developed that itemizes the acres harvested for each land ownership category, landowner, and biogeographic province, and breaks this harvest down by approximate decade, where the decade of harvest is known or can be reasonably estimated. In addition to the spatial information described above, statistics on the implementation of the Alaska Forest Resources and Practices Act and information on State timber sales in Southeast Alaska were collected from the Alaska Department of Natural Resources, Division of Forestry. This information is presented in Appendix C.

Original POG by Category

Next, the original POG was estimated on NFS and non-NFS lands in each biogeographic province and ecological subsection by category. This was done for the purpose of evaluating the level of disproportionate past harvest.

Original POG is defined in this EIS as the POG that existed, outside of the developed areas associated with towns, prior to all mapped timber harvest. Therefore, all young growth originating from timber harvest (mapped as HS1, HS2, and HS3 on NFS lands) was assumed to be original POG. Natural young growth (mapped as S1, S2, and S3 on NFS lands) was assumed to be in a steady state of succession and replacement; therefore, it was not assumed to be original POG. On the Tongass, about 570 acres of young growth were mapped as having been harvested between 1750 and 1900 and a total of about 10,800 acres were mapped as having been harvested after 1900 but prior to 1954, which is generally accepted as the approximate year that large-scale logging began. The vast majority (about 410,200 acres on the Tongass) of the harvest occurred from 1954 through the present. In addition, about 39,000 additional acres are mapped as young growth, but do not have a year of origin. These stands are primarily partial cut stands and are considered in the identification of original POG.

In addition to total POG (represented by the seven SDM types), two other categories of POG were used to represent the larger tree types: high-volume POG, which includes the three types with the largest trees (SD5S, SD5N, SD67), and large-tree POG, which is defined as SD67 by itself. To estimate original high volume- and large-tree POG, an estimate was first made of the percentage of past harvest in these

categories using the SizeDensity1954 layer, which was based on timber type mapping from the mid-1980s and other GIS layers. The following compositions of harvest were conservatively determined for NFS and non-NFS lands:

- For NFS lands, prior harvest was estimated to have been 30 percent large-tree POG and 75 percent high-volume POG.
- For non-NFS lands, prior harvest was estimated to have been 37 percent large-tree POG and 65 percent high-volume POG.

Future Harvest

The estimation of future harvest on non-NFS lands was made by examining the amount of POG remaining on these lands and making reasonable assumptions regarding the percentage of that POG that would be harvested in the future. It was conservatively estimated that 60 percent of all existing POG on state, private, other federal, and other non-NFS lands would be harvested within 100 years. All existing young growth and future harvest are expected to be harvested in the future and remain as young-growth.

Estimation of Past and Future Road Construction

The estimation of the direct, indirect, and cumulative effects of the alternatives associated with road construction required two major steps. First, it was necessary to assemble the inventory of existing roads on both NFS and non-NFS lands. The second step was the estimation of future road development for NFS lands under each alternative, and for all lands combined, including factors for future road development on non-NFS lands.

Road Inventory

For NFS lands, the existing road information from the Tongass GIS library was used. The “roads with core attributes RSW” layer was used for the inventory of system roads and the definition of maintenance levels to determine whether they were open or closed. The “non-routed other roads” layer was used to estimate additional unauthorized roads. For non-NFS lands, existing roads were inventoried using the following sources:

- Tongass GIS non-routed other roads layer, which contains most roads on non-NFS lands.
- Mapping of roads on Sealaska lands provided by Sealaska Regional Native Corporation.
- GIS layers for roads on many non-NFS lands in Southeast Alaska provided by State of Alaska.
- Other available GIS layers (e.g., ESRI’s StreetMap) were used for urban and rural areas around towns and settlements.
- Orthophoto and aerial photograph interpretation were used to “fill in holes” in other sources.

Based on input from the State of Alaska, it was assumed that half of the non-NFS road miles would remain open and half would

Future Road Construction and Reconstruction

Future road construction/reconstruction assumptions were different for old-growth versus young-growth harvest. The ratios derived are based on a review of Big Thorne and other recent timber sale projects.

For young growth, it was first assumed that 100% of all Maintenance Level 1 (ML 1) roads (closed roads) would be reconstructed if all young growth on the Forest were to be harvested. Then the miles of reconstruction for each alternative was extrapolated from this by using the proportion of young-growth to be harvested in that alternative. In addition, it was assumed that in some young-growth stands, construction of new roads would have less impact than reconstruction of old roads; thus an additional one mile of new road per 400 acres of young-growth harvest and one mile of new road over previously decommissioned road per 600 acres of harvest was assumed. It was also assumed that 10% of new

roads and new roads over decommissioned road grades would remain open, while the remaining 90% would be closed.

For old-growth harvest, future road construction was estimated based on the ratio of one mile of new road construction per 150 acres of harvest plus one mile of new road construction over previously decommissioned road grade per 800 acres of harvest. In addition, one mile of road reconstruction per 300 acres of harvest was assumed. Further, it was assumed that 10% of new roads and new roads over decommissioned road grades would remain open, while the remaining 90% would be closed.

On non-NFS lands, future increases in road density were projected after examining existing road densities and making reasonable assumptions regarding the additional road density that would be developed in the future. Estimates were conservatively high. Existing road density on non-NFS lands is 2.29 miles per square mile and the assumption was made road densities would increase by 1.3 miles per square mile within 100 years. All future non-NFS roads were assumed to remain open.

Deer Model Assumptions and Application

Interagency Deer Model

Forest Plan standards and guidelines require the use of the most recent version of the interagency deer winter habitat capability model to assess impacts to deer habitat (WILD4.XIV.A.2; USDA Forest Service 2008a). The interagency deer model was used in the EIS to (1) evaluate changes in deer winter habitat capability under each alternative, and 2) estimate the number of WAAs across the Tongass that meet the 18 deer per square mile index under the wolf standards and guidelines under each alternative.

The deer model was run for historic (1954) and current conditions, and to assess effects in 25 years (when harvested stands would reach the stem exclusion stage) and in 100 years (to encompass long-term effects over the planning horzon). Changes in winter habitat capability under the alternatives were based on comparisons to existing conditions for the analysis of direct effects (NFS lands only). For the analysis of cumulative effects changes in deer habitat capability were compared to historic (1954) conditions, the point at which large-scale timber harvest began (NFS and non-NFS lands). Analyses were run at the WAA scale, as this is the land division used by the ADF&G for deer inventories and planning, and the biogeographic province scale.

For the 2008 Forest Plan EIS a cross-walk was developed to reclassify the SDM model into the deer model vegetation categories (high-, medium-, low-volume old-growth). High-volume stands included SDM vegetation categories SD5N, SD5S, and SD67; medium volume stands include SD4N, SD4S, and SD5H; and low volume stands include SD4H. HSI scores from this model range from 0 to 1.3 but were standardized to range from 0 to 1.0 by dividing all values by 1.3, because outputs from such models represent a range from 0 to 100 percent habitat suitability, with higher values indicating higher habitat capability. Greater details are documented in the project planning record.

To estimate 1954 winter habitat capability, it was necessary to “grow back” the vegetation in previously harvested units. For this purpose, the recently developed volstrata1954 layer was used, which covered NFS and non-NFS lands. For all existing and future estimates on non-NFS lands deer habitat capability was set at zero, in order to be conservative and given that good quality and updated vegetation data in the correct format does not exist for non-NFS lands.

Future winter habitat capability was based on maximum timber harvest after full implementation of the Forest Plan under each alternative. For POG, it was assumed that the harvested acreage would be in the stand initiation (I) stage of stand development for 25 years and then remain in the stem exclusion stage (E) of stand development until it was harvested again. Intermediate stand treatments such as pre-commercial and commercial thinning are not reflected in the interagency deer model results because the model only assigns one value to harvested stands. That is, the model does not account for the conversion of stands currently in the stem exclusion stage back into the stand initiation stage, or account for the potentially beneficial effect of thinning treatments on deer winter habitat capability.

To describe existing conditions, an estimate of the percentage of 1954 habitat capability currently remaining was calculated by dividing the current HSI score for each WAA and biogeographic province by the 1954 HSI score. Likewise, to evaluate the effects of the alternatives, the future HSI score was divided by the current HSI score (direct and indirect effects) or by the 1954 HSI score (cumulative effects) for that WAA or biogeographic province, respectively. This was done at the 25- and 100-year time steps.

Modeled deer densities, in terms of deer per square mile, were calculated to evaluate the ability of the alternatives to comply with the wolf standard and guideline of maintaining habitat sufficient to support 18 deer per square mile. For this analysis, habitat capability in terms of modeled deer density was calculated by assuming a density of 100 deer per square mile for an HSI of 1.0. Only WAAs where wolves potentially occur (GMUs 1, 2, 3, and 5) were included and WAAs with naturally very low deer densities (WAAs 4302-4607) were excluded from the analysis.

FRESH Deer Model

The Forage Resources Evaluation System for Habitat (FRESH) model developed by the USDA Forest Service Pacific Northwest Research Station (Hanley et al. 2012) was also used to quantify the value of available deer habitat in the planning area (http://cervid.uaa.alaska.edu/deer/Home.aspx). The FRESH model is a food-based model that takes into account the quantity (biomass) and quality (digestible energy and digestible protein, two of the most common nutritional limiting factors for deer) of the available food resources in relation to user-specified metabolic requirements of deer (which depend on age, sex, season, and reproductive status). The model uses a linear algorithm to determine the suitable forage that can sustain deer at this metabolic requirement, and produces the number of deer days per unit area that the available food resources (within the habitat patch or landscape) are capable of supporting. One deer day represents the food required to support one animal for one day at the specified level of nutritional requirements. The output of the model is a “snapshot” of habitat conditions at one point in time which can be used to make a relative comparison of conditions within a habitat patch or landscape under different conditions (i.e., before and after implementation of a management activity).

Values for the available forage biomass and its nutritional quality (digestible energy and digestible protein concentrations) on the Tongass were based on a variety of sources including the Tongass Wide Young-Growth Study (2007, 2008, 2010, 2011, 2012, 2013), Prince of Wales Commercial Thin Study (Forest Sciences Lab Juneau 2014, unpublished), 2011 Tongass Young-growth Inventory (2011), Second Growth Management Project, Size-Density Accuracy Assessment and other unpublished studies from southeast Alaska (see the Project Record for more information). It is assumed that all available vegetation is potential food, and there is no accounting for long-term herbivore-plant dynamics (i.e., the effects of overbrowsing; Hanley et al. 2012). Thinning and logging slash have the potential to inhibit deer access; however, the current body of literature does not provide sufficient information for making adjustments to FRESH model output to reflect these limitations.

For this analysis, forage resources were analyzed with the GIS-based model application for the winter season. Spatial results from the Woodstock model were used directly in the GIS-based model. Deer metabolic requirements for winter were the following: dry matter digestibility directly 48 percent, digestible protein 1.8 percent and dry matter intake 525 g/day (see Hanley et al. 2012 for rationale and sources).

The FRESH model requires an estimate of snow depth on February 1 at sea level in a level open area. To reflect the geographic variation in snow depth in Southeast Alaska, the planning area was divided into six snow zones with average snow depth estimated for each under current climate conditions. Climate data from 1981-2010 were used to model PRISM-based “precipitation as snow” which was then converted to snow depth using the relationship of snow depth and elevation in the FRESH model snow sub-model (see metadata in the project record for additional information). The FRESH model then reduces the biomass of each forage in proportion to its height profile that is “buried” in snow (see Hanley et al. 2012 for details).

APPENDIX C
CUMULATIVE EFFECTS

Appendix C
Cumulative Effects

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ATTACHMENT

Attachment 1 Catalog of Past Harvest

Appendix C
Cumulative Effects

Introduction

Cumulative effects are defined in the Council on Environmental Quality (CEQ) regulations as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time” (40 CFR 1508.7). Cumulative actions are defined as “actions, which when viewed with other proposed actions, have cumulatively significant impacts and should therefore be discussed in the same impact statement” (40 CFR 1508.25). Cumulative effects are discussed in detail for each resource in the Environmental Impact Statement (EIS). This document discusses the projects considered and records which projects were considered for each resource.

Assumptions

Projects and actions included int the cumulative effects analysis were identified by reviewing past records, reviewing scoping comments, interviewing knowledgeable individuals, analyzing the existing condition of the project area using the Tongass and other geographic information system (GIS) layers, reviewing current plans, and, where necessary, making reasonable assumptions. These assumptions sometimes permit quantitative assessments.

Major assumptions used in this analysis are documented in Appendix B of the EIS, which also documents assumptions used for analyzing direct and indirect effects. Many of these assumptions are related to past and reasonably foreseeable timber harvest and road construction and reconstruction.

Timeframe for Analysis

The timeframe for this cumulative effects analysis encompasses past and future activities. Past activities include timber harvest and other activities that date back over 70 years, while future activities consider timber harvest at 25 years into the future, as well as at 100 years in the future. Most other future activities can only be considered as reasonably foreseeable about 25 years into the future because of uncertainties beyond that point.

Analysis Area

The area considered for cumulative effects analyses varies according to the resource being assessed. For most aquatic or watershed-related resources, the area within the proclaimed Forest boundary (approximately 17.9 million acres, including 1.2 million acres of non-National Forest System [NFS] lands) is used. For aquatic and watershed-related resources, this area is subdivided by 6th-field watersheds. For wildlife and other terrestrial resources, all of Southeast Alaska from Yakutat Bay southeast to the southeastern end of Alaska (approximately 21.6 million acres, including 4.8 million acres of non-NFS lands) is used as the study area for some analyses, although some analyses are based on the area within the Forest boundary, depending on the availability and quality of information. The Southeast Alaska area includes all of Glacier Bay National Park and the State, Bureau of Land Management, and other lands in the vicinity of Haines and Skagway. Often Wildlife Analysis Areas (WAAs) are used to summarize information within these study areas. In addition, biogeographic provinces are used to summarize cumulative effects information for biodiversity and some wildlife resources. For social and economic, recreation, and related human uses, all of Southeast Alaska and beyond, is given consideration for cumulative effects, especially regarding economic, market, and other factors.

Appendix C

Relevant Past, Present, and Reasonably Foreseeable Actions

Based on a review of published material and available information about the Tongass National Forest and adjoining lands on various agency websites and the scoping process, an initial list of existing, proposed, and reasonably foreseeable actions was compiled to be assessed for inclusion in this cumulative effects evaluation. Resources drawn from include the Forest Service Schedule of Proposed Actions (SOPA) report, April 2015 through March 2015 (Forest Service 2015); Tongass Integrated Plan (TIP) 2015-2019; the Alaska Department of Transportation and Public Facilities Project Statewide Transportation Improvement Program and Southeast Alaska Transportation Plan (ADOT&PF 2004, 2014); the Energy Resource Report for the Tongass National Forest (Tetra Tech 2015) the results of the scoping process, and other sources. In the case of timber harvest, this cumulative effects analysis attempts to quantify the effects of past human actions by adding up all prior actions on an annual or decadal basis (see Attachment 1). It also examines other past projects, but most importantly, by looking hard at current conditions, residual effects of past human actions and natural events are captured, regardless of which particular action or event contributed those effects. The Council on Environmental Quality issued an interpretive memorandum on June 24, 2005 regarding analysis of past actions which states, “agencies can conduct an adequate cumulative effects analysis by focusing on the current aggregate effects of past actions without delving into the historical details of individual past actions.” For these reasons, the primary method of analyzing past actions is based on the cumulative change in environmental conditions to the present, as described in the affected environment sections of the EIS. To keep the cumulative effects analysis useful, manageable, and concentrated on the effects that are meaningful, greater effort is given to future activities that are more certain and geographically close to the project with a focus on issues of greatest concern.

Table C-1 lists and describes the past projects and actions that are considered for analysis of cumulative effects. An updated catalog of past timber harvest is also provided in Attachment 1. Table C-2 lists the present and reasonably foreseeable projects and actions that are considered for cumulative analysis. Some projects or actions could be listed as past and present, as well as reasonably foreseeable (e.g., a currently operating mine that was built 20 years ago and is expected to continue operating into the reasonably foreseeable future). These projects are listed in Table C-2 and only completed projects or actions are listed in Table C-1. Table C-3 identifies the primary areas with potential interactions among the identified projects and actions and the primary resource areas.

Table C-1
Past Actions and Projects Considered in Cumulative Effects Analyses

Past Actions	Location	Year(s)	Description
Climate Change and Natural Processes			
Climate Change - General	Throughout Southeast Alaska	Past 25 years	Some climate models for Southeast Alaska have predicted rising temperatures, a 10 percent decrease in summer precipitation in portions of the region, and decreased soil moisture due to increased evaporation during warmer, dryer summer weather. These climate change-related processes may have already been initiated.
Yellow Cedar Decline	Primarily in a wide band from western Chichagof and Baranof Islands to the Ketchikan area	Past 50 years	Yellow-cedar decline and mortality, has dramatically changed many of the forests of Southeast Alaska and this decline is believed to have been climate related. Aerial surveys have mapped approximately 585,000 acres of decline in a wide band from western Chichagof and Baranof Islands to the Ketchikan area (USDA Forest Service and ADNR 2015). In 2014, approximately 20,000 acres of dying (i.e., active decline) yellow-cedar trees were mapped (USDA Forest Service and ADNR 2015).
Fire	Throughout Southeast Alaska	Historical	Because of high precipitation levels, fire has not been a major factor in shaping the forests of Southeast Alaska. However, approximately 400 to 500 acres have burned annually on the Tongass.
Insects and Disease	Throughout Southeast Alaska	Historical	A range of insects and diseases have taken their toll in Southeast Alaska forests; however, their severity has varied substantially over the years. Surveys have documented that individual insect pest species typically affect a few thousand acres to hundreds of thousands of acres each year. In addition to insects, stem decays cause substantial loss in all tree species in unmanaged stands. Tree death and stem breakage resulting from decay contribute to the structural diversity in stands and may be a major factor in small-scale disturbance in Southeast Alaska (Hennon and McClellan 2003). Dwarf mistletoe has also had high infestation levels in many hemlock stands below 500 ft in elevation (Shaw and Hennon 1991, Shaw et al. 2008).
Windthrow Events	Throughout Southeast Alaska	Historical	Small-scale windthrow events are very common throughout Southeast Alaska forests. These small events involve individual trees or small groups of trees. The open gaps in the canopy that result, allow young trees to colonize and fill the openings. Therefore, over time, complex, mixed-aged stands are produced. Insect and disease infestations are major contributing factors. These small-scale openings cover about 6 to 13 percent of Southeast Alaska forest canopies (Nowacki and Kramer 1998). Areas not protected by topographic barriers from the severe effects of infrequent, major storms are subject to large-scale windthrow events that cause catastrophic damage. Entire stands have blown down in the past, resulting in the regeneration of more even-aged stands with more uniform canopies (Nowacki and Kramer 1998). Both forms of windthrow are a part of the natural forest generation, growth, and development. Juday et al. (1998) concluded that there was a high risk of increased large-scale blowdown across Southeast Alaska as well as increased windthrow around harvest units as a result of climate change.
Watershed Effects	Throughout Southeast Alaska	Past 25 years	Climate change effects on water quality, water quantity, and fish to date are not clear, if they have occurred at all.

Table C-1 (continued)
Past Actions and Projects Considered in Cumulative Effects Analyses

Past Actions	Location	Year(s)	Description
Timber Harvest Activities			
Past Harvest – Tongass National Forest	Throughout Southeast Alaska, but concentrated on Prince of Wales and adjacent islands with large portions on Wrangell, Mitkof, Kupreanof, Kuiu, Revillagiggedo, and Baranof Islands.	Mostly 1954 to present	Approximately 462,000 acres of forest land have been harvested on the Tongass National Forest. Of these, about 422,000 acres were clearcut and are in even-aged management. Close to 70 percent of this harvest took place in the 1960s, 1970s, and 1980s; therefore the majority of young growth originating from harvest is 25 to 55 years of age. Less than 10 percent is greater than 55 and less than 4 percent is greater than 65 years of age. Attachment 1 to this appendix is a Catalog of Past Harvest for Southeast Alaska and is broken down by ownership and year/decade.
Past Harvest – State and Private Lands (non-NFS)	Throughout Southeast Alaska, wherever private or state lands are present; mostly on Prince of Wales and adjacent islands, Kupreanof, and Baranof Islands.	Mostly 1975 to present	Approximately 453,000 acres of forest land have been harvested on non-NFS lands within the Tongass National Forest boundary. The vast majority of this harvest took place in the 1980s and 1990s, so it is mostly younger than the young growth on NFS lands. Attachment 1 to this appendix is a Catalog of Past Harvest for all of Southeast Alaska and is broken down by ownership and year/decade.
Past Road Construction for Timber Harvest	Throughout Southeast Alaska, but concentrated on Prince of Wales and adjacent islands along Wrangell, Mitkof, Kupreanof, Kuiu, Revillagiggedo, Baranof, and other islands.	Mostly 1950s to present	To date, approximately 9,351 miles of road have been constructed on the Tongass National Forest and adjacent non-NFS lands within the Tongass boundary; 5,093 miles are on NFS land and 4,258 miles are on non-NFS land. The vast majority of these roads were developed for timber harvest purposes although these miles include state highways and local roads, in and around communities. Of the 9,351 miles, about 6,101 miles are open roads (2,321 miles on NFS land and 3,780 miles on non-NFS land). The remaining 3,249 miles are either closed roads or decommissioned roads.
Past Log Transfer Facility (LTF) Construction	Throughout Southeast Alaska, but concentrated on Prince of Wales and adjacent islands along Wrangell, Mitkof, Kupreanof, Kuiu, Revillagiggedo, Baranof, and other islands.	Mostly 1950s to present	LTFs are used to transfer logs to barges or rafts for towing. About 116 LTFs currently exist on the Tongass and there are 55 marine access points suitable for transferring logs to barges that have current permits on NFS lands. Another 10 marine access points no longer have permits. In addition, there are about 126 LTFs on State land and another group of LTFs exist on private lands.
Land Adjustments			
Misty Fjords National Monument Wilderness Inholdings	Ketchikan Misty Fjords Ranger District (KMRD)	2012	The 68-acre inholding located on the Eulachon River was acquired in 2012.

Table C-1 (continued)
Past Actions and Projects Considered in Cumulative Effects Analyses

Past Actions	Location	Year(s)	Description
Public Law 113-291	Many parts of the Tongass, but especially Prince of Wales and adjacent islands	2015	Public Law 113-291 amended ANCSA and provided Sealaska Regional Corporation final Section 14(h)(8) ANCSA entitlement. On March 9, 2015, Sealaska Corporation received its final ANSCA entitlement and conveyance of 70,075 acres. This conveyance affected multiple areas, LUDs and ranger districts on the Tongass. Public Law 113-291 also amended Section 508 of ANILCA by adding 8 new LUD II areas, containing 152,000 acres. The new LUD II designations changed the previous LUD designations for these lands (both development and non-development LUDs) to LUD II.
Other land adjustments	Tongass-wide	Prior to 2015	National Forest System Lands have been conveyed to Non-Federal parties under the Native Allotment Act, Alaska Native Claims Settlement Act (ANCSA), Alaska National Interest Lands Conservation Act (ANILCA) and other authorities.
Mining			
Various Mines	Tongass-wide	From 1867 to present	Mining history in Southeast Alaska dates back to the first mineral location in 1867, prior to the existence of the Tongass. During the late 1800s, gold was discovered in Southeast Alaska and mining ventures began to pop up. Historic mines include the Treadwell Mine and the Alaska Juneau Mine in Juneau; the Kensington and Jualin mines north of Juneau (recently reopened); the Ross-Adams uranium mine on Prince of Wales Island; the undeveloped Quartz Hill molybdenum deposit in the non-Wilderness Misty-Fjord National Monument; copper mines in the Ketchikan area; and many other deposits that were explored or developed throughout the Tongass. Mineral exploration and extraction has continued, at some level, since the first discoveries.
Energy			
Swan Lake Hydroelectric Project expansion	KMRD	2016-2017	In August 2015, the Federal Energy Regulatory Commission issued an order amending SEAPAs license for the project. SEAPA will expand the reservoir raising the spill elevation 15 feet and add 25% additional storage for winter hydropower generation, displacing up to 12,000 MWhrs of diesel generation (800,000 gallons) annually. The project will inundate about 93 acres of additional land of which about 26 acres is federal lands within the Tongass National Forest.
Recreation and Tourism			
Cruise Ships	Tongass-wide, especially the major ports	Late 1880s to present	The Southeast Alaska cruise ship industry has developed and grown to substantial levels. The first cruise ships sailed in the late 1880s and the number of passengers now numbers about one million per year. Modern cruise ships began sailing to Alaska in the 1970s and the number of passengers reached about 500,000 in 1995 and the number of passengers doubled in the next 20 years. These ships use the major ports of Southeast Alaska.
Outfitter Guides	Tongass-wide	Mostly 1920s to present	Outfitters and guides have provided services throughout Southeast Alaska for many years, beginning as hunting and fishing guides in the early years, they have expanded the services they provide. The Forest Service issues special use permits to manage the number and distribution of outfitters and guides.

Table C-1 (continued)
Past Actions and Projects Considered in Cumulative Effects Analyses

Past Actions	Location	Year(s)	Description
Helicopter Landings and Tours	Mostly the Juneau Ranger District		With the advent of the cruise ship industry, helicopter tours and landings developed into a secondary industry. The majority of these occur in the Juneau Icefield. Helicopter landing tours also occur in a number of locations elsewhere on the Forest, including the Skagway Icefield and Baird Patterson Glaciers. These tours involve high volumes of people concentrated at specific locations for short periods of time, typically two to four hours.
Dispersed Recreation and Subsistence Gathering	Tongass-wide	Mostly 1920s to present	Dispersed recreation has steadily increased in Southeast Alaska along with the growth of the tourism industry, the growth of communities, and the development of roads. Gathering of subsistence resources has also increased, although more slowly, with the growth of subsistence communities.
Fishing and Recreation Lodges	Tongass-wide	Mostly 1940s to present	Numerous lodges have been developed on private lands adjacent to the Tongass National Forest. Some of these have gone out of business but most continue to operate.
Recreation site development and closure	Tongass-wide	Mostly 1960s to present	A wide range of recreation facilities have been developed on the Tongass. They include 25 campgrounds and camping areas, 10 day-use areas, 35 picnic sites, 155 cabins/lookouts, 44 shelters, 68 trailheads and 885 miles of trail, and many other facilities.
Community Development			
Community Development	Tongass-wide	Mostly 1890s to present	Settlement and community development in Southeast Alaska occurred primarily from the late 1800s to the present. Mining, fishing, and fish canneries were the primary early factors encouraging settlement, later followed by logging. Today there are 32 communities in Southeast Alaska. Eleven of these communities have less than 100 people ranging up to Juneau with over 33,000. The footprint of these communities ranges in size from a few acres to several thousand acres. Road development is associated with community development and is covered above under timber harvest activities.
Wildlife Habitat Enhancement and Regulatory Actions			
Habitat Enhancement	Tongass-wide	Mostly 1960s to present	A range of wildlife habitat enhancement projects has occurred throughout Southeast Alaska. These projects were designed to improve forest and riparian habitats for wildlife. They include extensive pre-commercial thinning, some with wide-spacing, riparian thinning and snag creation.
State Hunting and Trapping and Federal Subsistence Regulations	Tongass-wide	Mostly 1959 to present	State regulations have been in place since shortly after Statehood (1959) to control hunting and trapping activities. These regulations set bag limits and seasons and limit the hunting and trapping methods that can be used in pursuit of game animals, game birds, and furbearers. Prior to Statehood, federal regulations governed hunting and trapping. In addition, a Federal Subsistence Board establishes subsistence regulations for many areas of the State.

Table C-1 (continued)
Past Actions and Projects Considered in Cumulative Effects Analyses

Past Actions	Location	Year(s)	Description
Watershed and Aquatic Habitat Improvement and Aquatic Regulatory Actions			
Restoration Projects	Tongass-wide	Mostly 1960s to present	The Forest Service has conducted numerous watershed improvement projects including: watershed monitoring and assessments; instream and riparian rehabilitation; placement of large woody debris in streams; conducting landslide assessments; improving fish passage in streams (creating jump pools, barrier modifications, culvert replacements); stream and lake stocking, and lake fertilization; decommissioning roads; and maintaining fish passage structures. The number and locations of projects have varied year to year based on funding and need.
State Fishing and Federal Subsistence Regulations	Tongass-wide	Mostly 1959 to present	State regulations have been in place since shortly after Statehood (1959) to control fishing and shellfish collecting. These regulations set bag limits and seasons and limit the methods that can be used to pursue resources. Prior to Statehood, federal regulations governed fishing. In addition, a Federal Subsistence Board establishes subsistence regulations for many areas of the State.

Table C-2
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Climate Change and Related Natural Perturbations			
General – Climate Change	Throughout Southeast Alaska	2016 and beyond	Some climate models for Southeast Alaska predict rising temperatures, a 10 percent decrease in summer precipitation in portions of the region, and decreased soil moisture due to increased evaporation during warmer, dryer summer weather. These factors may lead to an increase in fire frequency and severity, further yellow-cedar decline, higher rates of insect and disease infestations, more severe windthrow events, and effects on stream flows, water temperature, and fisheries.
Yellow Cedar Decline	Primarily in a wide band from western Chichagof and Baranof Islands to the Ketchikan area	2016 and beyond	As the climate continues to warm, cedar decline is likely to continue to spread, especially in the south and east. Conversely, yellow-cedar appears to be spreading northward as climate warms, into areas that retain snow longer into the spring.
Fire	Throughout Southeast Alaska	2016 and beyond	Approximately 400 to 500 acres burn annually on the Tongass National Forest. Due to climate change, there may be an increased risk of forest fires but the effects are likely to be minor at the forest level.
Insects and Disease	Throughout Southeast Alaska	2016 and beyond	If the warming trend continues, damage to trees from insects and rot are likely to increase, both from species currently present in Southeast Alaska and from new species invading the area from other parts of North America or elsewhere. Consider stem and root decay, hemlock dwarf-mistletoe; heart rot; spruce beetle; spruce aphids; and species not yet present.
Windthrow Events	Throughout Southeast Alaska	2016 and beyond	Both small-scale and large-scale forms of windthrow are a part of the natural forest generation, growth, and development. Juday et al. (1998) concluded that there was a high risk of increased large-scale blowdown across Southeast Alaska as well as increased windthrow around harvest units as a result of climate change.
Watershed Effects	Throughout Southeast Alaska	2016 and beyond	Climate change will likely produce increases in air temperature in the winter months with increases in precipitation expected in the fall and winter, with much of the precipitation occurring as rain instead of snow (EcoAdapt 2014). The warmer air temperatures would contribute to the melting of glaciers, higher peak flows in the fall and winter in most streams other than glacier-fed streams, and lower summer flows primarily in snow-melt and rain dominated watersheds (Shanley and Albert 2014, Shanley et al. 2015). In addition, the warmer air temperatures may result in increased stream temperatures, but the degree this would occur depend greatly on local factors and any potential increase may be lessened by the potential increases in rainfall occurring in the summer and fall (EcoAdapt 2014). Climate change could also result in sea-level rise, which could inundate estuarine rearing areas for fish. Other effects on fish are likely to be both positive and negative and have a high degree of uncertainty.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Timber Harvest Activities including roads and other actions on NFS lands (thinning and commercial thinning not differentiated)			
Forecasted acres to be harvested and roads to be constructed during the next 25 years and during the next 100 years for each alternative.			
Projected Future Harvest and Road Construction and Reconstruction over 25 years for Each Alternative	Lands suitable for timber productions on the Tongass under each alternative (see suitable land maps)	2016 - 2040	Alternative 1: YG Harvest = 9,669 acres, OG Harvest = 38,527 acres, Road Construction = 345 miles, Road Reconstruction = 160 miles Alternative 2: YG Harvest = 63,787 acres, OG Harvest = 15,027 acres, Road Construction = 385 miles, Road Reconstruction = 256 miles Alternative 3: YG Harvest = 53,734 acres, OG Harvest = 16,599 acres, Road Construction = 355 miles, Road Reconstruction = 229 miles Alternative 4: YG Harvest = 40,760 acres, OG Harvest = 23,255 acres, Road Construction = 354 miles, Road Reconstruction = 209 miles Alternative 5: YG Harvest = 43,316 acres, OG Harvest = 23,813 acres, Road Construction = 369 miles, Road Reconstruction = 219 miles (Young growth = YG; Old growth = OG)
Projected Future Harvest and Road Construction and Reconstruction over 100 years for Each Alternative	Suitable forest lands on Tongass under each alternative (see suitable land maps)	2016 - 2115	Alternative 1: YG Harvest = 209,882 acres, OG Harvest = 62,851 acres, Road Construction = 1,372 miles, Road Reconstruction = 887 miles Alternative 2: YG Harvest = 335,344 acres, OG Harvest = 32,609 acres, Road Construction = 1,656 miles, Road Reconstruction = 1,191 miles Alternative 3: YG Harvest = 313,216 acres, OG Harvest = 35,568 acres, Road Construction = 1,586 miles, Road Reconstruction = 1,129 miles Alternative 4: YG Harvest = 234,885 acres, OG Harvest = 42,597 acres, Road Construction = 1,316 miles, Road Reconstruction = 900 miles Alternative 5: YG Harvest = 284,144 acres, OG Harvest = 42,479 acres, Road Construction = 1,520 miles, Road Reconstruction = 1,058 miles (Young growth = YG; Old growth = OG)
Timber harvest projects that are being implemented or are in planning stages for the next five years. These are included within the 25-year and 100-year estimates above.			
Big Thorne	Thorne Bay Ranger District (TBRD)	2015-2019+	100-150 MMBF offered for sale. 70 miles of roads maintained and 64 miles of roads restored. Restore and enhance 4.6 miles of stream; thin 10 riparian acres and 1,000 upland acres. Remove 8 fish barrier culverts. (Approximately 98 MMBF has already been sold as of November 2015)
Greater Staney Area	TBRD	2016-2019+	47 MMBF offered for sale. Restore and enhance 2 miles of stream; thin 54 riparian acres and 1,500 upland acres. Remove or replace 28 fish barrier culverts.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Wrangell Island	Wrangell Ranger District (WRD)	2016-2019+	70 MMBF offered for sale and 1,300 acres for precommercial thinning. 52 miles of roads maintained; 9.5 miles of roads reconstructed; 12 miles of roads stored; and 2.5 miles of road decommissioned. Remove or replace 9 fish barrier culverts.
Zarembo	WRD	2016-2019+	60 MMBF offered for sale and 2,000 acres for precommercial thin. 80 miles of road maintained; 18 miles of road stored. Restore and enhance 7.6 miles of stream; thin 162 riparian acres and 1,460 upland acres. Replace 48 fish barrier culverts.
TwelveMile	CRD	2017-2019+	13 miles of roads maintained. Restore and enhance 2.5 miles of stream; thin 40 riparian acres and 65 upland acres. Remove or replace 10 fish barrier culverts.
Neck Lake/Alder Creek	TBRD	2016-2019+	40 MMBF offered for sale. 18 miles of roads maintained and 29 miles or roads stored. Restore and enhance 1.5 miles of stream; thin 50 riparian acres and 300 upland acres. Replace 4 fish barrier culverts.
Kuiu Roaded	Petersburg Ranger District (PRD)	2016-2019+	25 MMBF offered for sale. 5 miles of roads maintained; 18 miles of roads reconstructed; 9 miles of roads stored; and 7 bridges replaced. Restore and enhance 3 miles of stream. Remove or replace 10 barrier culverts.
Thomas Bay	PRD	2017-2019+	15 MMBF offered for sale (5 MMBF young growth). 4 miles of roads maintained and 4 miles or roads stored. Replace 2 bridges. Restore and enhance 1 mile of stream; thin 1,000 riparian acres and 312 upland acres. Replace 2 fish barrier culverts.
Traitors Cove	KMRD	2017-2019+	10 MMBF offered for sale. 4 miles of roads maintained and 4 miles of roads stored. Restore and enhance 3 miles of stream; thin 100 riparian acres. Remove or replace 8 barrier culverts.
Kosciusko Vegetation Management & Watershed Improvement Project	TBRD	2016-2019+	Manage roughly 1,500 acres of young-growth for multiple resource objectives and harvest an estimated 75 acres of old-growth, to meet Forest Plan objectives and assist in the transition to a young-growth industry.
Iris and Shelikof	Sitka Ranger District (SRD)	2015-2019	Restoration and Enhancement thinning. 20 miles of roads stored. Restore and enhance 4 miles of stream; thin 500 riparian acres and 3,500 upland acres. Remove one fish barrier culvert.
Saddle Lakes	KMRD	2016-2019	47 MMBF offered for sale. 17 miles of new NFS road, 10 miles of temporary road and reconditioning 10.5 miles of existing NFS roads.. Restore and enhance 3 miles of stream. Remove or replace 28 barrier culverts.
Shrimp Bay	KMRD	2015-2018	10 MMBF offered for sale and 1,000 acres precommercial thin. 3 miles of roads maintained. Remove or replace 5 barrier culverts.
Kennel Creek	Hoonah Ranger District (HRD)	2015-2018	Restoration and Enhancement thinning. 4 miles of road maintained. Restore and enhance 0.5 miles of stream; thin 350 upland acres. Remove 4 barrier culverts.
Sitka Ranger District	SRD	2017-2019	Precommercial thin 400 acres. Watershed restoration including riparian thinning, instream work, and pond and road work.
Mitkof	PRD	2015	10 MMBF offered for sale.
Control Lake-Angel Wings	TBRD	2015	0.5 MMBF offered for sale.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Control Lake – Rush Firewood	TBRD	2015	0.2 MMBF offered for sale.
Navy	WRD	2015	10 MMBF offered for sale.
Elf Point	KMRD	2017	10 MMBF offered for sale.
Heceta	TBRD	2018	5 MMBF offered for sale.
Vallenar	KMRD	2019	20 MMBF offered for sale.
No Name Bay	PRD	2020+	70 MMBF offered for sale.
Frosty Bay	WRD	2020+	10 MMBF offered for sale.
Timber Harvest Activities – State and Private Lands			
Forecasted acres to be harvested and roads to be constructed during the next 25 years and during the next 100 years for each alternative. These sales will be governed by the Alaska Forest Resources and Practices Act which is designed to protect fish habitat, water quality and promote reforestation.			
Projected Future Harvest and Road Construction and Reconstruction over 25 years for Each Alternative	Almost all State and Private Lands within the proclaimed Tongass Boundary	2016 - 2040	The majority of State and Private harvest will be old growth Alternative 1: Harvest = 56,234 acres Road Construction = 584 miles Road Reconstruction = 61 miles Alternative 2: Harvest = 56,234 acres Road Construction = 584 miles Road Reconstruction = 61 miles Alternative 3: Harvest = 56,234 acres Road Construction = 584 miles Road Reconstruction = 61 miles Alternative 4: Harvest = 56,234 acres Road Construction = 584 miles Road Reconstruction = 61 miles Alternative 5: Harvest = 56,234 acres Road Construction = 584 miles Road Reconstruction = 61 miles

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Projected Future Harvest and Road Construction and Reconstruction over 100 years for Each Alternative	Almost all State and Private Lands within the Tongass Boundary	2016 - 2115	The majority of State and Private harvest will be old growth Alternative 1: Harvest = 224,937 acres Road Construction = 2,335 miles Road Reconstruction = 245 miles Alternative 2: Harvest = 224,937 acres Road Construction = 2,335 miles Road Reconstruction = 245 miles Alternative 3: Harvest = 224,937 acres Road Construction = 2,335 miles Road Reconstruction = 245 miles Alternative 4: Harvest = 224,937 acres Road Construction = 2,335 miles Road Reconstruction = 245 miles Alternative 5: Harvest = 224,937 acres Road Construction = 2,335 miles Road Reconstruction = 245 miles
Specific State of Alaska timber sales that are being implemented or are in planning stages for the next five years. These are included within the 25-year and 100-year estimates above.			
Coffman Cove	Prince of Wales Island	2015+	1,628 acre sale. 13.1MMBF. 5.8 mile of road. Approximately 412 acres of old growth timber with an estimated volume of 7,177 MBF will be sold in 2015.
South Thorne Bay Area	Prince of Wales Island (Kasaan Peninsula)	2015+	153 acre sale. 3.0MMBF(Active)
North Thorne Bay	Prince of Wales Island (Thorne Bay)	2015+	300-acre sale. 5.8MMBF
North Hollis	Prince of Wales Island (Hollis)	2015+	263 acres of old growth; 108 acres of young growth. 5.3 MMBF old growth; 2.2 MMBF young growth.
Kosciusko Island	Kosciusko Island (Prince of Wales)	2015, 2016	1,383 acres; 28 MMBF. New log transfer facility and sort yard.
Heceta	Heceta Island (Prince of Wales)	2015, 2016	2,600 acres. 30 MMBF. (10 MMBF old growth, 20 MMBF young growth)
El Capitan	Prince of Wales Island	2016	1,700 acres; 5 miles of new road. 17 MMBF.
Whale Pass	Prince of Wales Island	2016	441 acres; 2 miles new road; 6.6 MMBF.
Exchange Cove	Prince of Wales Island	2016	116 acres.1.2 MMBF.
Bostwick Bay	Gravena Island (Ketchikan)	2017	583 acres. 5 miles new road. Road to cross Bostwick Creek. 8.9MMBF.
Vallenar	Gravena Island (Ketchikan)	2017	300 acres old growth. 300 acres young growth. 12 MMBF. 8 miles new road; 1.5 mile reconstructed road.
Little Coal Bay	Prince of Wales (Kasaan Bay)	2017	1,000 acres. 5.2 MMBF

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Kitkun Bay	Prince of Wales (Cholmondeley Sound)	2017	1,051 acres. Volume not reported.
Port Dolores	Prince of Wales (Sumez Island)	2018	1,109 acres 12.2 MMBF Old Growth; 3.8 MMBF young growth.. 4.7 miles of new road on state land. 1,500 feet of new road on NFS land.
Hook Arm	Dall Island	2018	960 acres. 11.5MMBF. 4.4 miles new road.
Naukati	Prince of Wales (Naukati)	2018	162 acres. 3.7MMBF. Short spur roads.
Control Lake	Prince of Wales (Control Lake)	2018	170 acres 3.4MMBF. 1.4 miles new road.
Mitkof Island	Mitkof Island (Petersburg)	2019	210 acres; 4.0 MMBF
Thomas Bay	Thomas Bay (Petersburg)	2019	816 acres; 20.2 MMBF (4.9 MMBF old growth; 15.3 MMBF young growth). 3.7 miles new road; 1.7 Miles road reconstructed.
Earl West Cove	Wrangell Island	2019	700 acres; 12.5 MMBF; 5.0 miles new road
Leask Cove	Revillagigedo Island (George Inlet)	2019	316 acres; 6.3 MMBF; 1.8 mile spur road
Small Sales and Other Sales	Variable	2016 and beyond	Right-of-way sales; blowdown sales; sales less than 10 acres. Five to 10 small sales totaling approximately 2.0 MMBF will be offered for Calendar Year 2018.
Alaska Mental Health Trust Commercial Forestlands	Variable	2015 and beyond	The Alaska Mental Health Trust Land Office is comparable to a private forestland manager. Approximately 265 million board feet of the Trust's commercial forestland lies in southeast Alaska. A large portion of this forestland is community and environmentally sensitive. The Trust will be looking at these sensitivities in more detail in the future. The Trust Land Office is currently overseeing a timber sale contract near Icy Cape (18,000 acres). To better understand the forestland assets owned by the Trust, forest resource inventory work is currently underway in the vicinity of Wrangell and Thorne Bay.
Sealaska and other Alaska Native Corporations	Native Corporation Lands	2015 and beyond	Projected harvest of 6.2 MMBF in 2016 increasing annually to 7.2 MMBF by 2030.
Land Adjustments			
Alaska Mental Health Trust land exchange	Ketchikan, Petersburg, Wrangell, Sitka, Juneau, Myers Chuck, Naukati, and Hollis, Alaska	2015-2020 or later	The Alaska Mental Health Trust is working with the Tongass National Forest on a land exchange proposal involving 18,000 acres of Non-Federal lands in scenic viewsheds and approximately 20,000 acres of NFS land across eight communities in Southeast Alaska. In order to better align land ownership patterns with the inherent missions of both the Forest Service and the Alaska Mental health Trust Authority. An equal value land exchange has been proposed. In 2015, A Feasibility Analysis was completed, and both parties signed an Agreement to Initiate.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Remaining land conveyances due to the Alaska Statehood Act	Tongass-wide	2015-2025 or later	The State of Alaska was granted and entitled to select up to 400,000 of National Forest Lands in Alaska for the purpose of furthering the development of and expansion of communities under the Alaska Statehood Act (43 CFR 2627.1(a)) On the Tongass National Forest, the State of Alaska has approximately 12,145 acres remaining of land entitlement under the Act. The adjudication process and conveyances are initiated by the Bureau of Land Management, Alaska State Office.
Cube Cove land acquisition	Admiralty Island	2016 or later	The 22,890 acres of surface estate within the Admiralty Island National Monument and Kootznoowoo Wilderness would be purchased from Shee Atiká, Inc. The purpose of this acquisition is to conserve and enhance significant scenic, recreation, cultural and wildlife/plant resources within National Monument/Wilderness and to protect wilderness values from development. In addition to the surface land purchase between the Forest Service and Shee Atika, the subsurface estate owner, Sealaska Regional Corporation, has expressed interest to potentially exchange the subsurface estate at Cube Cove for other Surface Estate on the Tongass National Forest.
Sealaska Land Entitlement Finalization Act	Tongass-wide	2015-2017	Within two years of enactment of the "Carl Levin and Howard P. 'Buck' McKeon National Defense Authorization Act for Fiscal Year 2015", Sealaska may submit applications for the conveyance under section 14(h)(1)(A) of the Alaska Native Claims Settlement Act (43 U.S.C. 1613(h)(1)(A)) of not more than 76 cemetery sites and historical places, amounting to approximately 500 acres.
Boomer land donation	Sitka Ranger District, Chichagof Island	2016+	In 2012, the Federal Energy Regulatory Commission (FERC) issued an order amending the license for the Blue Lake Hydroelectric Project. FERC's environmental assessment for the project identified 362 acres of National Forest System lands inundated by the raising of water levels in the reservoir as an unavoidable impact that would require mitigation. The mitigation was needed to offset the permanent loss of the timber, recreation, subsistence, wildlife habitat, and botanical resources around the Blue Lake Creek valley and other areas of the lakeshore. The City of Sitka proposed to donate 48 acres of land on Chichagof Island as mitigation for the inundated area. The lands proposed for donation are three parcels known as "Basoiniuer No. 1, Basoiniuer No. 2, and Golden West" on City planning documents. These three parcels are municipal-owned lands within the West Chichagof-Yakobi Wilderness. These lands are referred to as the Boomer lands.
Alaska Veteran Native Allotment Land Equity Act	Tongass-wide	Not scheduled	The proposed legislation is specific to National Forest Lands in Alaska, but includes a clause regarding approval of formerly rejected Native Allotment Cases under the "Shields v. USA" case. The Shields case closed 200 Native allotment cases under the 1906 Native Allotment Act which were applied for under ancestral uses v. individual use and occupancy. Most Shield's cases were previously identified on the Tongass. Native Allotment applications are 160 acres each and thus approximately up to 32,000 acres of the Tongass that could become private lands in the future. This legislation was introduced in May 2015 and has not become law.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Unrecognized Southeast Alaska Native Communities Recognition and Compensation Act	Native Villages of Haines, Ketchikan, Petersburg, Tenakee, and Wrangell	Not scheduled	The proposed legislation would amend the Alaska Native Claims Settlement Act to permit the Native residents of each of the Native Villages of Haines, Ketchikan, Petersburg, Tenakee, and Wrangell, Alaska, to organize as Urban Corporations and to receive certain settlement land pursuant to this Act. The entitlement would consist of one township of land or 23,040 acres (total approximate acres are 184,320) and require the conveyance of all roads, trails, log transfer sites, leases, and appurtenances on or related to the land conveyed to the new urban corporations. This legislation was introduced in May 2015 and has not become law.
Alaska State Forest Proposal	Prince of Wales Island	Not scheduled	State officials or interests have at times advocated the establishment of an additional Alaska State Forest to be managed to provide income for state government programs. One concept for such a management unit was for a 2-million-acre area on or near Prince of Wales Island, which would require transfer of extensive areas of current Tongass National Forest System lands to the State. To date, no federal legislation to implement such a proposal has been introduced in Congress and this action is not considered reasonably foreseeable.
Alaska Native Allotment Act conveyances	Tongass-wide	Unknown	The Alaska Native Allotment Act provided for Native individuals who had occupied lands prior to their designation as national forest to apply for conveyance of up to 160 acres, under conditions prescribed by the Act and federal regulations. As of August 2015, about 45 Native allotment cases remain on the Tongass National Forest and are pending adjudication by the Bureau of Land Management. This number may increase due to unknown circumstances by either quite title action, re-instatement applications, or new legislative proposals.
Mining (Tongass)			
Greens Creek Mine (Active)	Admiralty Island	Present – 2025 or beyond	Underground polymetalic mine. Ore is processed on site and exported by sea. Waste water, waste rock and tailings are managed onsite. Power is supplied by hydroelectric infrastructure and diesel generators. The Greens Creek Land Exchange Act of 1995 allows mining to continue through 2095. Annually, the mine continues exploration in and around the mine.
Kensington Mine (Active)	Juneau	Present-2025 or beyond	Underground gold mine. Waste water, waste rock and tailings are managed onsite. Power is provided diesel generators. Annually, the mine continues exploration in and around the mine.
Bokan Mountain	Prince of Wales (Kendrick Bay)	Unknown	Bokan Mountain is a potential rare earth mine. Developers estimate 190 employees. It would be powered by liquid natural gas (LNG) generators.
Niblack	Prince of Wales (Moira Sound)	Unknown	Niblack Project is a potential polymetalic mine. Developers estimate 200 employees.
Other Locatable Minerals	Tongass-wide	Continual	Mining exploration is expected to continue in many areas of the Forest. Existing projects submit annual operating plans that describe exploration activities.
Mineral Materials	Various	Continual	New and existing mineral materials sources will be developed. Stone, crushed rock, gravel and other saleable materials will be used for road building and maintenance and

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
			other purposes. Materials may be used in-service (by the Forest Service) or sold to private parties.
Mining (Canada)			
Kerr-Sulphurets-Mitchell	Unuk River watershed	Present-2068 or beyond	Seabridge Gold proposes to reopen this polymetallic mine in northwest British Columbia about 18 miles east of the Alaska/B.C. border. These deposits would be mined as open pits until later in the project when the Mitchell deposit would continue as an underground mine.
Red Chris	Stikine River Watershed	2015-2045	Imperial Metals recently opened the Red Chris copper/gold mine in northwest British Columbia.
Tulsequah Chief	Taku River Watershed	Unknown	Chieftan Metals Inc. seeks to open this underground polymetallic mine in northwest British Columbia about 40 miles northeast of Juneau.
Energy			
Angoon Hydroelectric Project	Admiralty Island, Thayer Creek, (Angoon	Unknown	The Alaska National Interest Lands Conservation Act (ANILCA), Section 506(a)3(B) granted Kootznoowoo Inc. the right to develop hydroelectric resources on Admiralty Island at Thayer Creek. The Forest Service completed a final environmental impact statement (FEIS) to disclose the effects of the proposed project. A record of decision (ROD) was released in May 2009. The ROD authorizes the construction of a 1 megawatt run of river hydroelectric facility on Thayer Creek, approximately six miles north of Angoon that includes a diversion dam, penstock, powerhouse, underground transmission lines and access roads.
Bell Island Geothermal	KMRD	Unknown	No specific projects are proposed at this time, although SEAPA is conducting preliminary investigations for geothermal power generation.
Crooked Creek/Jim's Lake Hydroelectric Project	Elfin Cove	2017	In February 2015, the community of Elfin Cove proposed to develop a project that consists of two hydroelectric systems in series with a total capacity of about 140 kilowatts (kW). Common to both systems is about 12,000 feet of power line. The upper system is a run-of-river hydroelectric project that would include the following major components: 1) A natural water feature diversion on Crooked Creek that is about 20 feet long by 4 feet tall by 4 feet wide diversion. 2) About 1,250 foot long 12-inch diameter penstock 3) about 14-foot by 14-foot powerhouse 4) A tailrace measuring about 3 feet deep by 8 feet wide by 50 feet long. 5) Access trails, temporary construction roads, and other appurtenant features necessary to provide a complete and functional system. The lower system is a storage hydroelectric project that would include the following major components: 1) a siphon intake 2) about 2,050 foot long 14-inch diameter penstock 3) an approximately 24-foot by 24-foot powerhouse. 4) a tailrace measuring 3 feet deep by 8 feet wide by 150 feet long. 5) Access trails, temporary construction roads, and other appurtenant features necessary to provide a complete and functional system. The project would occupy about 60 acres of federal lands.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Indian River hydroelectric	Tenakee Springs	2017-2018	The community of Tenakee Springs has been developing a 180 kilowatt run-of-river hydroelectric project on Indian River. The Project will supply approximately 90% of the city's electricity, reducing diesel use by about 31,400 gallons annually. The project does not occupy federal lands,
Kake-Petersburg Transmission Line Intertie	Mitkof and Kupreanof Islands, Petersburg and Wrangell Ranger Districts	2016 and beyond	The Southeast Alaska Power Agency (SEAPA) proposed to build a new electric transmission line that would connect the isolated electric system presently serving the city of Kake with SEAPA's interconnected electric network, in or near Petersburg. The November 2014 Draft EIS analyzed three action alternatives that range from 52 miles to 60 miles in total length, with 82 to 88 percent of their total length located on NFS lands. The proposed transmission line would be built to transmit power at either 69 - or 138–kilovolts. All three action alternatives follow existing NFS system roads to the extent possible, with the length along existing roads ranging from 58 percent to 72 percent of the total. The action alternatives all cross Inventoried Roadless Areas. No new roads would be built under any of the alternatives. Construction access in unroaded areas would be via temporary shovel trails and matting panels, with helicopter support, as needed. The action alternatives would all involve marine crossings.
Soulé River Hydroelectric Project	KMRD	Unknown	In February 2011, Soule Hydro, LLC filed an application for an original license with the Federal Energy Regulatory Commission for its proposed 77MW hydropower project on the Soule River, about nine miles southwest of Hyder, Alaska (FERC Project No. 13528). Major project features include: (1) a main dam 265-feet-tall by 903-feet-long; (2) a saddle dam about 2,024 feet long; (3) an intake structure; (4) a reservoir with a surface area of about 1,072 acres (5) an 16-foot-diameter by 11,400-foot-long water conduit tunnel; (6) a 3.1-mile-long access road; (7) a 80-foot-wide by 160-foot-long powerhouse; a tailrace that will discharge into the river mouth; (8) three 138 kilovolt substation next to the powerhouse; (9) marine access facilities that include a staging area, boat ramp, barge basin for offloading barges, and float for small watercraft; (10) temporary log transfer facility; (11) a 10-mile-long, 138 kilo-volt submarine cable to Stewart, B.C. (about two miles will be in Canadian waters) to connect with a BC Hydro substation. The project would occupy 1,257 acres of federal lands within the Tongass National Forest.
Sweetheart Lake Hydroelectric Project	Juneau Ranger District	Unknown	In October 2015 the Federal Energy Regulatory Commission released the draft EIS for the proposed project located on Lower Sweetheart Lake and Sweetheart Creek, (FERC Project No. 13563). Major project features include: (1) A 280-foot-wide, 111-foot-high dam; (2) a 525-foot-long, 10-foot-high, 10-foot-wide arched reservoir outlet tunnel; (3) a 45-foot-long, 25-foot-wide, 16-foot-high intake structure; (4) a 9,612-foot-long, 15-foot-wide, 15-foot-high underground power tunnel; (5) an 896-foot-long, 9-foot-diameter penstock; (6) three 160-foot-long, 7- to 9-foot-diameter buried penstocks (7) a 160-foot-

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
			long, 60-foot-wide, 30-foot-high powerhouse; (8) three 7.1-MW Francis turbines with 6.6-MW generators with a total installed capacity of 19.8 MW; (9) a 541-foot-long, 30- to 90-foot-wide rock tailrace; (10) a 4,400-foot-long coastal road from the powerhouse to a dock/landing site, located on the east shore of Gilbert Bay; (11) an 8.69-mile-long, 138-kilovolt (kV) transmission line traversing Gilbert Bay, the Snettisham Peninsula, and Port Snettisham, consisting of: (a) two buried segments, totaling 4,800 feet in length; (b) two submarine segments; and (c) one 15,400-foot-long overhead segment; (12) a 22,000-square-foot fenced switchyard adjacent to the powerhouse; (13) a 4,225-square-foot caretaker's facility near the dock; (14) a 4,800-foot-long, 12.47-kV service transmission line extending from the powerhouse to the dock and caretaker's facility; (15) a 10,000-foot-long, 12.47-kV service transmission line; and (16) a 400-square-foot shelter at the dam site. The project would occupy 2,058.24 acres of federal lands within the Tongass National Forest and 131.18 acres of tideland and submerged lands of the state of Alaska.
Communication Sites			
Existing and Future Communications Sites	Tongass-wide	Present and continuing	Sites approved for telecommunication facilities are characterized by antennas, electronic transmitters, equipment shelters, and a variety of electronic communication support equipment. Proposals for new communications uses on the Tongass National Forest will be encouraged to co-locate on an approved communications site, unless the proponent demonstrates that communication sites approved in the Forest Plan are not technically feasible due to geographic location, or are incompatible with the requested use. Currently, there are 75approved communication sites on the Tongass.
Transportation			
Regional Transportation Systems	Tongass-wide	2015 and continuing	The State of Alaska will continue to maintain and improve its regional transportation system including road and marine systems.
Angoon Airport	Angoon	2016	The Alaska Department of Transportation and Public Facilities proposed a land-based airport for Angoon. In January 2015 the Federal Aviation Administration released a Draft Environmental Impact Statement (EIS) for public comment. The preferred alternative identified in the DEIS is on private lands. . Two alternative airport locations being considered are within the Admiralty Island National Monument and Kootznoowoo Wilderness. ADOT&PF submitted an ANILCA Title XI application for the alternative in Wilderness.
Clark Bay Ferry Terminal Parking Expansion	Hollis (Prince of Wales)	Est. 2016	The Alaska Department of Transportation and Public Facilities intends to expand the existing parking area at the Clark Bay (Hollis) ferry terminal by about 50 parking spaces.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Juneau Access Improvement Project (ADOT&PF Federal Highway Administration)	Juneau/Haines	2016 or later	Extend Glacier Highway/State Route 7 northward from its current terminus to the north side of the Katzehin River delta, in a series of stages, under the preferred alternative in the Final Environmental Impact Statement (EIS) and construct terminal near Katzehin River.
Gravina Access	Gravina and Revillagigedo Islands	2016 or later	Design and construct improved access to Gravina Island
Ketchikan to Shelter Cove Road (Cleveland Peninsula Shelter Cove D1 easement)	KMRD, Cleveland Peninsula	2015??	Construct between 9 and 10 miles of new, single lane, unpaved roadway and bridges and upgrade between 10 and 19 miles of existing logging roads to connect Revilla Road near Ketchikan to the Forest Service Road system at Shelter Cove on Carroll Inlet.. Approximately 1.61 miles of road would be routed through wetlands or other jurisdictional waters of the United States, while the other 5.68 miles would be routed through uplands. The project is an identified road segment supporting implementation of the 2004 Southeast Alaska Transportation Plan
Naukati Bay Road	Naukati (Prince of Wales)	2015?	Upgrade and pave Naukati West Access Road to a two lane road between the North POW Road and the Naukati Seaplane Float.
Sitka-Katlian Bay Road	Sitka	2016 or later	In 2010 the State of Alaska Department of Transportation and Public Facilities (DOT&PF) was granted a D-1 easement for highway and utility planning purposes (Sitka – Rodman Bay). This road corridor was identified as a Proposed State Road Corridor in the 2008 Forest Plan Land Use Designations map and given a Transportation and Utility System LUD. DOT&PF is preparing a "…State Projects Environmental Checklist to address impacts and issues associated with…" building about nine miles of unpaved single-lane road from the end of the existing Sitka road system at Halibut Point Road, extending east along the south shoreline of Katlian Bay, crossing the Katlian River, and ending four miles east of the Katlian Bay. Two and one-half miles of this proposed road crosses National Forest System lands. Some of the road is in the Sitka Urban Inventoried Roadless Area (331).
Kake Access Project	Kake (Kupreanof Island)	unknown	In January 2013 the Western Federal Lands Highway Division of the Federal Highway Administration (FHWA) issued a notice to advise the public that FHWA would prepare an Environmental Impact Statement (EIS) for a proposed transportation project to improve access to and from the community of Kake in Southeast Alaska Construct approximately 27 miles of new single lane, unpaved roadway and bridges and improve approximately 26 miles of existing logging roads on the north end of Kupreanof Island to provide Kake road access to Petersburg via a short shuttle ferry link. The very low volume road is intended to improve Kake's surface transportation access to Petersburg, the regional transportation system.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
Sandy Beach Road	Thorne Bay (Prince of Wales Island)	2015?	Reconstruct and realign FSR30 from the intersection of Freeman Drive MP 0.0 in Thorne Bay to MP 0.5 at the City of Thorne Bay's Bypass Loop Road and city limits. This is the first phase of the fully designed 6.58 miles of trails and roadwork to the Sandy Beach.
Alaska Marine Highway and Interisland ferry	Southeast Alaska (non-NFS)	2016 and beyond	Construction of new passenger terminal buildings and other improvements in Angoon and Kake; various marine terminal improvements in Ketchikan, Skagway, Gustavus, Sitka, Juneau, Tenakee Springs, and Haines; maintenance and refurbishment of vessels.
Other Transportation Projects	Southeast Alaska (NFS and non-NFS)	2016 and beyond	The Forest Service will conduct transportation projects which will vary year to year based on funding and need. These include maintaining or improving existing roads and bridges, placing roads in storage, paving existing dirt roads, and improving fish passage at culverts. The State and local communities will also implement various transportation projects such as paving or resurfacing roads, road realignments, safety improvements, vessel and marine terminal improvements, etc.
Recreation and Tourism			
Cruise Ships	Tongass-wide	2015 and beyond	Expected growth in recreation and tourism businesses based on continued growth in the cruise ship industry
Outfitter Guides	Tongass-wide	2015 and beyond	Outfitter guide services may include guided hunts or trapping, camping, fishing, cross country skiing, hiking or other commercial recreational activities. Outfitter and guide services are generally provided within ½-mile inland of the shoreline but extend further for some activities (e.g. goat hunting, canoeing, freshwater fishing).
Helicopter Landings and Tours	Mostly the Juneau Ranger District	2015 and beyond	About 17,000 landings occur on the Juneau Icefield for tours and activities annually (based on 2004-2007 data), which accounts for about 75% of the helicopter tours/landings in Southeast Alaska. Helicopter landing tours also occur in a number of locations elsewhere on the Forest, including the Skagway Icefield and Baird Patterson Glaciers.
Dispersed Recreation and Subsistence Gathering	Tongass-wide	2015 and beyond	There may be increasing recreational demand as the tourism industry continues to grow and increasing recreation around communities with population growth. Gathering of subsistence resources is also expected to increase, although more slowly than recreation, with the growth of subsistence communities.
Fishing and Recreation Lodges	Tongass-wide	2015 and beyond	Numerous lodges occur on private lands adjacent to the Tongass. It is expected that most of these lodges will continue to operate, and new lodges will be opened, providing additional recreational opportunities.
Recreation site development and closure	Tongass-wide	2015 and beyond	Continued use, maintenance and improvement of existing developed recreation sites (e.g., cabins, campgrounds, visitor centers, trails, and viewing areas, and other facilities), closures of such sites, or creation of new may occur. Similarly, the State or communities may develop, improve, or modify recreation sites.
Communities			
Population changes	Tongass-wide	Ongoing	Human settlement expansion is expected to occur around the region's larger cities, such as Juneau and Sitka, with residential expansion also expected as a result of state land auctions.

Table C-2 (continued)
Present and Reasonably Foreseeable Actions and Projects Considered in Cumulative Effects Analyses

Present/Reasonably Foreseeable Actions	Location	Year(s)	Description
State land Offerings	Tongass-wide	Ongoing	The State periodically offers land for settlement and development. Often, these lands are adjacent to NFS lands. No NFS lands are included in these State land offerings.
POW Borough	Prince of Wales Island	unknown	The Prince of Wales Community Advisory Council is investigating the formation of a Prince of Wales Borough. (speculative)
Wildlife			
Pre-commercial thinning		2016 and beyond	The Tongass Integrated Plan provides details on planned precommercial thinning projects that would benefit wildlife. A summary of acres by Ranger district is below. HRD: About 2,270 acres; JRD: About 640 acres (Couverden); KMRD: About 2,780 acres; PRD: About 3,890 acres; TBRD: About 6,000 acres (Big Thorne Stewardship); WRD: About 1,460 acres.
Mitkof Island Deer Habitat Enhancement	Petersburg Ranger District	2016	Treat up to 1,114 acres of young-growth stands to benefit deer.
Sport and Subsistence Harvest	Tongass-wide	2016 and beyond	Sport and subsistence harvests will continue throughout the forest. Prediction of the future extent and intensity of such activities has a high degree of uncertainty associated with it on a Forest-wide basis over a broad time scale.
Watershed Restoration			
Restoration Projects	Tongass-wide	2016 and beyond	Annually, the Forest Service will conduct watershed improvement projects including: watershed monitoring and assessments; instream and riparian rehabilitation; placement of large woody debris in streams; conducting landslide assessments; improving fish passage in streams (creating jump pools, barrier modifications, culvert replacements); decommissioning roads; and maintain fish passage structures. The number of locations and number of projects will vary year to year based on funding and need.

Table C-3
Interactions Between Resources and Actions or Projects

Actions or Projects	Climate and Air	Geology/Karst	Soils	Water	Wetlands	Fish	Plants	Forest Health	Biodiversity	Wildlife	Lands	Timber	Transportation	Energy/Utility Lines	Minerals	Recreation/ Tourism	Scenery	Subsistence	Heritage	Roadless	Wilderness	Socioeconomic	Communities
PAST ACTIONS																							
Climate Change and Natural Processes																							
Climate Change - General	x								x	x													
Yellow Cedar Decline								x	x			x											
Fire	x							x	x			x											
Insects and Disease								x	x			x											
Windthrow								x	x			x											
Watershed Effects				x		x			x	x													
Timber Harvest Activities																							
Past Harvest - NFS		x		x	x	x	x		x	x		x				x	x	x	x	x		x	x
Past Harvest – non-NFS		x		x	x	x	x		x	x		x				x	x	x	x	x		x	x
Past Road Construction/Use		x		x	x	x	x		x	x		x	x			x	x	x	x	x		x	x
Past LTF Construction/Use				x	x	x	x		x	x						x	x	x	x	x		x	x
Land Adjustments																							
Misty Fjords National Monument Wilderness Inholdings (2012)											x										x		
Public Law 113-291		x		x		x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x
Boomer Land Donation									x	x	x												
Other land adjustments				x		x			x	x	x	x					x			x		x	x
Mining																							
Various Mines		x	x	x	x	x	x		x	x		x			x	x	x						
Recreation and Tourism																							
Cruise Ships	x									x						x					x	x	x
Outfitter Guides										x						x					x	x	
Helicopter Landings and Tours										x						x					x	x	x
Dispersed Recreation and Subsistence Gathering						x	x		x	x						x		x					
Fishing and Recreation Lodges						x	x		x	x		x				x	x		x			x	
Recreation site development and closure						x	x		x	x		x				x	x		x			x	

Table C-3 (continued)
Interactions Between Resources and Actions or Projects

Actions or Projects	Climate and Air	Geology/Karst	Soils	Water	Wetlands	Fish	Plants	Forest Health	Biodiversity	Wildlife	Lands	Timber	Transportation	Energy/Utility Lines	Minerals	Recreation/ Tourism	Scenery	Subsistence	Heritage	Roadless	Wilderness	Socioeconomic	Communities
Community Development																							
Community Development									x	x	x		x	x		x	x	x	x			x	x
Wildlife Habitat Enhancement and Regulatory Actions																							
Habitat Enhancement					x	x	x		x	x								x					
State Hunting/Trapping and Federal Subsistence Regulations										x								x					
Watershed and Aquatic Habitat Improvement and Aquatic Regulatory Actions																							
Restoration Projects				x	x	x												x					
State Fishing and Federal Subsistence Regulations					x	x												x					
PRESENT AND REASONABLY FORESEEABLE ACTIONS																							
Climate Change and Natural Processes																							
General – Climate Change	x			x		x		x	x	x		x		x		x						x	x
Yellow Cedar Decline								x	x			x											
Fire	x							x	x			x											
Insects and Disease								x	x			x											
Windthrow Events								x	x			x											
Watershed Effects				x		x			x	x													
Timber Harvest Activities																							
Future Harvest - NFS		x		x	x	x	x		x	x		x				x	x	x	x	x		x	x
Future Harvest – non-NFS		x		x	x	x	x		x	x		x				x	x	x	x	x		x	x
Future Road Construction/Use		x		x	x	x	x		x	x		x	x			x	x	x	x	x		x	x
Future LTF Construction/Use				x	x	x	x		x	x						x	x	x	x	x		x	x
Land Adjustments																							
Land Adjustments		x		x		x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x
Mining																							
Various Mines		x	x	x	x	x	x		x	x		x			x	x	x						
Energy																							
Hydroelectric Projects	x		x	x	x	x	x		x	x		x	x	x		x	x		x	x		x	x
Other Renewable Energy Projects	x		x	x	x	x	x		x	x		x	x	x		x	x		x	x		x	x

Table C-3 (continued)
Interactions Between Resources and Actions or Projects

Actions or Projects	Climate and Air	Geology/Karst	Soils	Water	Wetlands	Fish	Plants	Forest Health	Biodiversity	Wildlife	Lands	Timber	Transportation	Energy/Utility Lines	Minerals	Recreation/ Tourism	Scenery	Subsistence	Heritage	Roadless	Wilderness	Socioeconomic	Communities
Transmission Lines			x	x	x	x	x		x	x		x	x	x		x	x		x	x		x	x
Communication Sites																							
Existing and Future Communications Sites							x		x	x				x			x		x				
Transportation																							
Regional Transportation Systems	x	x	x	x	x	x	x		x	x			x	x		x	x	x	x			x	x
Local Transportation Systems	x	x	x	x	x	x	x		x	x			x	x		x	x	x	x			x	x
Alaska Marine Highway & Interisland Ferry	x					x				x			x			x						x	x
Recreation and Tourism																							
Recreation Developments/Actions	x					x	x		x	x		x				x	x	x	x		x	x	x
Communities																							
Community Expansion/Development	x		x	x	x	x	x		x	x	x		x	x		x	x	x	x			x	x
Wildlife																							
Pre-commercial thinning & habitat enhancement							x		x	x		x						x					
Sport and Subsistence Harvests										x								x					
Watershed Restoration																							
Restoration Projects			x	x	x	x	x		x	x													

Attachment 1

Catalog of Past Harvest

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Attachment 1
Catalog of Past Harvest

Introduction

This appendix presents a catalog of past harvest for Southeast Alaska. It is based on updated and extensive mapping of past harvest based on the Tongass GIS library, GIS data layers provided by Sealaska Regional Native Corporation, the State of Alaska, and Audubon Alaska/The Nature Conservancy, as well as supplemental interpretation of orthophotography and other aerial photography. It is also based on tabular information collected from the State of Alaska, Department of Natural Resources regarding state harvests and harvests under the Alaska Forest Resources and Practices Act. Appendix B provides more detailed information on the inventory methodology.

Part II presents a tabular summary of information provided by the State of Alaska Department of Natural Resources, Division of Forestry.

Part I – Acreage of Past Harvest by Ownership Category, by Landowner, by Biogeographic Province, by Approximate Decade

Table I-1
Acreage of Past Harvest by Landowner

Ownership Category	Landowner	Est. Approx. Harvest Decade	Acres Harvested
Yakutat Forelands Biogeographic Province			
Tongass National Forest	Tongass National Forest	1950s	28
	Tongass National Forest	1970s	553
	Tongass National Forest	1980s	1,812
	Tongass National Forest	1990s	229
	Tongass National Forest	2000s	987
	Tongass National Forest	--	18
	Total NFS Lands		**3,627**
State of Alaska	State of Alaska	1970s–1990s	1,315
	Total State Lands		**1,315**
	Yak-tat Kwaan Village Corporation	1980s	12,541
	Other	--	134
Private & Other Lands	**Total Private/Other Lands**		**12,675**
	TOTAL PROVINCE HARVEST		**17,618**
Yakutat Uplands Biogeographic Province			
Tongass National Forest	Tongass National Forest	1980s	665
	Tongass National Forest	1990s	173
	Tongass National Forest	2000s	552
	Tongass National Forest	--	21
	Total NFS Lands		**1,411**
State of Alaska	**Total State Lands**		0
Private & Other Lands	**Total Private/Other Lands**		0
	TOTAL PROVINCE HARVEST		**1,411**
East Chichagof Island Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	1,016
	Tongass National Forest	1950s	1,527
	Tongass National Forest	1960s	6,053

Table I-1
Acreage of Past Harvest by Landowner

Ownership Category	Landowner	Est. Approx. Harvest Decade	Acres Harvested
	Tongass National Forest	1970s	13,232
	Tongass National Forest	1980s	10,501
	Tongass National Forest	1990s	11,713
	Tongass National Forest	2000s	60
	Tongass National Forest	--	105
	Total NFS Lands		**44,207**
State of Alaska	State of Alaska	1980s	200
	State of Alaska	1990s	227
	State of Alaska	2000s	70
	Total State Lands		**497**
Private & Other Lands	Hoonah	--	252
	Huna Totem Village Corporation	--	11,449
	Sealaska Regional Corporation	1970s	1,352
	Sealaska Regional Corporation	1980s	7,670
	Sealaska Regional Corporation	1990s	6,400
	Sealaska Regional Corporation	2000s	6,825
	Other Private Owners	--	81
	Total Private/Other Lands		**37,007**
	TOTAL PROVINCE HARVEST		**81,711**
West Chichagof Island Biogeographic Province			
Tongass National Forest	**Total NFS Lands**		**0**
State of Alaska	**Total State Lands**		**0**
Private & Other Lands	**Total Private/Other Lands**		**0**
	TOTAL PROVINCE HARVEST		**0**
East Baranof Island Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	197
	Tongass National Forest	1950s	223
	Tongass National Forest	1960s	8,158
	Tongass National Forest	1970s	2,725
	Tongass National Forest	1990s	2,227
	Total NFS Lands		**13,530**
State of Alaska	**Total State Lands**		**0**
Private & Other Lands	Other Private Land Owners	--	2
	Total Private/Other Lands		**2**
	TOTAL PROVINCE HARVEST		**13,532**
West Baranof Island Biogeographic Province			
Tongass National Forest	Tongass National Forest	1950s	1,085
	Tongass National Forest	1960s	9,812
	Tongass National Forest	1970s	5,556
	Tongass National Forest	1980s	10
	Total NFS Lands		**16,978**
State of Alaska	State of Alaska	1980s	696
	State of Alaska	1990s	204
	Total State Lands		**900**
Private & Other Lands	Shee Atika Village Corporation	1980s	1,184
	Other Private Owners	--	271
	Total Private/Other Lands		**1,455**
	TOTAL PROVINCE HARVEST		**19,332**

Table I-1
Acreage of Past Harvest by Landowner

Ownership Category	Landowner	Est. Approx. Harvest Decade	Acres Harvested
Admiralty Island Biogeographic Province			
Tongass National Forest	Tongass National Forest	Prior to 1950	3,202
	Tongass National Forest	1950s	771
	Tongass National Forest	1960s	3,305
	Tongass National Forest	1970s	1,108
	Tongass National Forest	1990s	17
	Tongass National Forest	2000s	105
	Tongass National Forest	--	88
	Total NFS Lands		**8,595**
State of Alaska	**Total State Lands**		**0**
Private & Other Lands	Shee Atika Village Corporation	1980s–1990s	20,080
	Other Private Owners	--	110
	Total Private/Other Lands		**20,190**
	TOTAL PROVINCE HARVEST		**28,785**
Lynn Canal Biogeographic Province			
Tongass National Forest	Tongass National Forest	1960s	2,129
	Tongass National Forest	1970s	1,177
	Tongass National Forest	1980s	545
	Tongass National Forest	1990s	1,527
	Total NFS Lands		**5,377**
State of Alaska	State of Alaska	1980s	214
	Total State Lands		**214**
Private & Other Lands	Other Private Owners	1990s	335
	Total Private/Other Lands		**335**
	TOTAL PROVINCE HARVEST		**5,926**
North Coast Range Biogeographic Province			
Tongass National Forest	Tongass National Forest	1950s	221
	Total NFS Lands		**221**
State of Alaska	State of Alaska	--	24
	Total State Lands		**24**
Private & Other Lands	Goldbelt Village Corporation	1980s	20,389
	City and Borough of Juneau	--	1
	Other Land Owners	--	147
	Total Private/Other Lands		**20,537**
	TOTAL PROVINCE HARVEST		**20,782**
Kupreanof/Mitkof Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	1,573
	Tongass National Forest	1950s	1,096
	Tongass National Forest	1960s	6,781
	Tongass National Forest	1970s	10,183
	Tongass National Forest	1980s	8,335
	Tongass National Forest	1990s	5,539
	Tongass National Forest	2000s	2,234
	Total NFS Lands		**35,742**
State of Alaska	State of Alaska	1980s	3,648
	State of Alaska	1990s	884
	State of Alaska	2000s	54
	Total State Lands		**4,587**
Private & Other Lands	Kake	--	126

Table I-1
Acreage of Past Harvest by Landowner

Ownership Category	Landowner	Est. Approx. Harvest Decade	Acres Harvested
	Petersburg	--	484
	Kake Village Corporation	1970s–1990s	17,471
	Sealaska Regional Corporation	<1980	3,755
	Sealaska Regional Corporation	1980s	1,831
	Sealaska Regional Corporation	1990s	551
	Sealaska Regional Corporation	2000s	6,009
	Other Private Owners	--	823
	Total Private/Other Lands		**31,050**
	TOTAL PROVINCE HARVEST		**71,379**
Kuiu Island Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	2,570
	Tongass National Forest	1950s	344
	Tongass National Forest	1960s	3,428
	Tongass National Forest	1970s	8,989
	Tongass National Forest	1980s	7,852
	Tongass National Forest	1990s	4,644
	Tongass National Forest	2000s	667
	Total NFS Lands		**28,494**
State of Alaska	State of Alaska	--	9
	Total State Lands		**9**
Private & Other Lands	Sealaska Regional Corporation	<1980	22
	Other Private Owners	--	113
	Total Private/Other Lands		**135**
	TOTAL PROVINCE HARVEST		**28,638**
Central Coast Range Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	159
	Tongass National Forest	1950s	910
	Tongass National Forest	1960s	3,574
	Tongass National Forest	1970s	1,087
	Tongass National Forest	1980s	164
	Tongass National Forest	1990s	586
	Total NFS Lands		**6,479**
State of Alaska	State of Alaska	1970s–1980s	1,421
	Total State Lands		**1,421**
Private & Other Lands	Other Land Owners	--	13
	Total Private/Other Lands		**13**
	TOTAL PROVINCE HARVEST		**7,913**
Etolin Island and Vicinity Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	2,565
	Tongass National Forest	1950s	1,728
	Tongass National Forest	1960s	2,593
	Tongass National Forest	1970s	12,666
	Tongass National Forest	1980s	8,964
	Tongass National Forest	1990s	6,532
	Tongass National Forest	2000s	1,016
	Tongass National Forest	--	4
	Total NFS Lands		**36,066**
State of Alaska	State of Alaska		3,764
	Total State Lands		**3,764**

Table I-1
Acreage of Past Harvest by Landowner

Ownership Category	Landowner	Est. Approx. Harvest Decade	Acres Harvested
Private & Other Lands	Wrangell		643
	Other Land Owners		68
	Total Private/Other Lands		**712**
	TOTAL PROVINCE HARVEST		**40,542**
North Central Prince of Wales Island Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	1,772
	Tongass National Forest	1950s	11,460
	Tongass National Forest	1960s	50,216
	Tongass National Forest	1970s	47,190
	Tongass National Forest	1980s	35,623
	Tongass National Forest	1990s	33,507
	Tongass National Forest	2000s	4,343
	Tongass National Forest	--	15
	Total NFS Lands		**184,125**
State of Alaska	State of Alaska	--	15,384
	Total State Lands		**15,384**
Private & Other Lands	Hydaburg	--	48
	Kasaan	--	16
	Thorne Bay	--	180
	Haida Village Corporation	1980s–1990s	2,465
	Kavilco Village Corporation	1990s	11,811
	Klawock-Heenya Village Corporation	1980s–1990s	12,073
	Sealaska Regional Corporation	<1980	3,240
	Sealaska Regional Corporation	1980s	32,741
	Sealaska Regional Corporation	1990s	24,452
	Sealaska Regional Corporation	2000s	22,835
	Shaan Seet Village Corporation	1980s–1990s	6,858
	Other Private Land Owners	--	3,304
	Total Private/Other Lands		**120,022**
	TOTAL PROVINCE HARVEST		**319,531**
Revilla Island/Cleveland Peninsula Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	2,181
	Tongass National Forest	1950s	6,812
	Tongass National Forest	1960s	6,389
	Tongass National Forest	1970s	8,443
	Tongass National Forest	1980s	5,827
	Tongass National Forest	1990s	11,477
	Tongass National Forest	2000s	4,470
	Tongass National Forest	--	60
	Total NFS Lands		**45,658**
State of Alaska	State of Alaska		4,043
	Total State Lands		**4,043**
Private & Other Lands	Ketchikan	--	39
	Sealaska Regional Corporation	<1980	151
	Cape Fox Village Corporation	1980s–1990s	13,266
	Other Land Owners	1980s–1990s	7,406
	Total Private/Other Lands		**20,862**
	TOTAL PROVINCE HARVEST		**70,563**

Table I-1
Acreage of Past Harvest by Landowner

Ownership Category	Landowner	Est. Approx. Harvest Decade	Acres Harvested
Southern Outer Islands Biogeographic Province			
Tongass National Forest	Tongass National Forest	1950s	569
	Tongass National Forest	1960s	3,737
	Tongass National Forest	1970s	3,058
	Tongass National Forest	1980s	5,737
	Tongass National Forest	1990s	1,683
	Tongass National Forest	2000s	354
	Total NFS Lands		**15,138**
State of Alaska	State of Alaska	1990s	2,102
	Total State Lands		**2,102**
Private & Other Lands	Haida Village Corporation	--	4
	Klawock-Heenga Village Corporation	--	366
	Sealaska Regional Corporation	2000s	31
	Shaan Seat Village Corporation	1980s–1990s	3,324
	Total Private/Other Lands		**3,725**
	TOTAL PROVINCE HARVEST		**20,965**
Dall Island and Vicinity Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	77
	Tongass National Forest	1950s	79
	Tongass National Forest	1960s	213
	Total NFS Lands		**369**
State of Alaska	**Total State Lands**		**0**
Private & Other Lands	Haida Village Corporation	1980s–1990s	365
	Klukwan Villa Village Corporation	1980s–1990s	17,265
	Sealaska Regional Corporation	<1980	630
	Sealaska Regional Corporation	1980s	4,549
	Sealaska Regional Corporation	1990s	1,831
	Sealaska Regional Corporation	2000s	8,011
	Other Land Owners	--	265
	Total Private/Other Lands		**32,916**
	TOTAL PROVINCE HARVEST		**33,285**
South Prince of Wales Island Biogeographic Province			
Tongass National Forest	Tongass National Forest	<1950	410
	Tongass National Forest	1950s	60
	Tongass National Forest	1960s	467
	Tongass National Forest	1970s	368
	Tongass National Forest	1980s	276
	Tongass National Forest	1990s	994
	Tongass National Forest	2000s	716
	Tongass National Forest	--	1
	Total NFS Lands		**3,292**
State of Alaska	State of Alaska	--	351
	Total State Lands		**351**
Private & Other Lands	Sealaska Regional Corporation	<1980	79
	Sealaska Regional Corporation	2000s	79
	Haida Village Corporation	1980s–1990s	589
	Kootznoowoo Village Corporation	1980s–1990s	13,491
	Other Land Owners	--	25
	Total Private/Other Lands		**14,184**

Table I-1
Acreage of Past Harvest by Landowner

Ownership Category	Landowner	Est. Approx. Harvest Decade	Acres Harvested
	TOTAL PROVINCE HARVEST		**17,827**
North Misty Fiords Biogeographic Province			
Tongass National Forest	Tongass National Forest	1950s	81
	Tongass National Forest	1960s	960
	Tongass National Forest	1980s	68
	Tongass National Forest	--	260
	Total NFS Lands		**1,370**
State of Alaska	State of Alaska	--	818
	Total State Lands		**818**
Private & Other Lands	Sealaska Regional Corporation	1980s	16
	Sealaska Regional Corporation	2000s	8
	Total Private/Other Lands		**23**
	TOTAL PROVINCE HARVEST		**2,211**
South Misty Fiords Biogeographic Province			
Tongass National Forest	**Total NFS Lands**		**0**
State of Alaska	**Total State Lands**		**0**
Private & Other Lands	**Total Private/Other Lands**		**0**
	TOTAL PROVINCE HARVEST		**0**
Ice Fields Biogeographic Province			
Tongass National Forest	Tongass National Forest	1960s	1,732
	Tongass National Forest	1970s	1,311
	Tongass National Forest	1980s	996
	Tongass National Forest	2000s	5
	Total NFS Lands		**4,044**
State of Alaska	**Total State Lands**		**0**
Private & Other Lands	**Total Private/Other Lands**		**0**
	TOTAL PROVINCE HARVEST		**4,044**
Glacier Bay/Fairweather Range Biogeographic Province			
Tongass National Forest	**Total NFS Lands**		**0**
State of Alaska	**Total State Lands**		**0**
Private & Other Lands	Glacier Bay N.P.	--	200
	Total Private/Other Lands		**200**
	TOTAL PROVINCE HARVEST		**200**
Chilkat River Complex Biogeographic Province			
Tongass National Forest	**Total NFS Lands**		**0**
State of Alaska	State of Alaska	1980s–2000s	17,069
	Total State Lands		**17,069**
Private & Other Lands	BLM	--	136
	Glacier Bay N.P.	--	568
	Private/Other	--	2,864
	Total Private/Other Lands		**3,568**
	TOTAL PROVINCE HARVEST		**20,637**

Part II – Statistics on the Alaska Forest Resources and Practices Act Implementation and State Timber Sales in Southeast Alaska

Part II presents a tabular summary of information provided by the State of Alaska Department of Natural Resources, Division of Forestry. Statistical information is not available for harvests prior to the Alaska Forest Resources and Practices Act (AFRPA), nor for some years since the Act. Tables II-1 through II-5 provide statistics regarding the AFRPA, as it has been applied to private and other lands in Southeast Alaska. Tables II-6 through II-18 provide information on State timber sales in Southeast Alaska.

Table II-1
Forest Practices Act – Summary Statistics for Southeast Alaska, 1991–1998

	1991	1992	1993	1994	1995	1996	1997	1998
New Notifications								
SSE	103	117	145	124	131	146	123	87
NSE	2	0	8	0	3	1	0	0
TOTAL	**105**	**117**	**153**	**124**	**134**	**147**	**123**	**87**
Harvest Acreage in New Notifications Received								
SSE	21,016	37,971	28,769	33,038	22,745	30,509	26,034	16,291
NSE	110	0	824	100	227	80	0	0
TOTAL	**21,126**	**37,971**	**29,593**	**33,138**	**22,972**	**30,589**	**26,034**	**16,291**
# Inspections								
SSE	146	134	98	119	93	90	42	56
NSE	2	0	8	1	5	0	0	0
TOTAL	**148**	**134**	**106**	**120**	**98**	**90**	**42**	**56**
# Variation Trees Reviewed (=approved, denied, and other (e.g., withdrawn)								
SSE	350	1,344	3,581	1,660	1,054	1,116	2,571	4,113
NSE	83	0	0	0	0	0	0	0
TOTAL	**433**	**1,344**	**3,581**	**1,660**	**1,054**	**1,116**	**2,571**	**4,113**

Table II-2
Forest Practices Act – Summary Statistics for Southeast Alaska, 1999–2006

	1999	2000	2001	2002	2003	2004	2005	2006
New Notifications								
SSE	79	104	36	43	51	47	43	51
NSE	0	0	19	10	6	6	5	3
TOTAL	**79**	**104**	**55**	**53**	**57**	**53**	**48**	**54**
Harvest Acreage in New Notifications Received								
SSE	11,705	20,542	5,599	7,667	12,197	30,488	27,733	37,313
NSE	0	3,779	9,619	5,839	1,780	1,969	344	413
TOTAL	**11,705**	**24,321**	**15,218**	**13,506**	**13,977**	**32,457**	**28,077**	**37,726**
# Inspections								
SSE	32	89	44	43	58	35	59	20
NSE	0	0	25	24	11	9	13	9
TOTAL	**32**	**89**	**69**	**67**	**69**	**44**	**72**	**29**
# Variation Trees Reviewed (=approved, denied, and other (e.g., withdrawn)								
SSE	1,522	330	103	58	336	948	411	0
NSE	0	0	144	20	199	17	0	0
TOTAL	**1,522**	**330**	**247**	**78**	**535**	**965**	**411**	**0**

Table II-3
Forest Practices Act – Summary Statistics for Southeast Alaska, 2007–2014

	2007	2008	2009	2010	2011	2012	2013	2014
New Notifications								
SSE	34	27	32	61	54	32	14	14
NSE	7	2	8	8	6	3	5	0
TOTAL	41	29	40	69	60	33	19	14
Harvest Acreage in New Notifications Received								
SSE	10,263	18,988	7,752	17,532	5,577	8,373	4,717	1,724
NSE	1,039	211	1,858	1,740	2,241	6,379	40	0
TOTAL	11,302	19,199	9,610	19,272	7,818	14,752	4,757	1,724
# Inspections (Department of Forestry)								
SSE	39	42	29	37	18	6	20	31
NSE	8	5	3	1	2	1	3	3
TOTAL	47	47	32	38	18	7	23	34
# Variation Trees Reviewed (=approved, denied, and other (e.g., withdrawn)								
SSE	0	538	222	14	6	46	312	202
NSE	0	0	0	0	0	0	243	0
TOTAL	0	538	222	14	6	46	555	202

NR=Not reported in ADOF Annual Report

Table II-4
Forest Practices Act – Road Miles Summary for State of Alaska, 1997–2006

Road Miles Notified	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
SSE	156	104	101	130	39	58	71	69	34	25
NSE	0	0	0	0	104	20	10	3	4	3
Mat-Su/SW	13	3	28	0	0	3	5	13	12	46
Kenai-Kodiak	195	50	146	44	65	146	96	57	25	11
COASTAL	364	157	275	174	208	227	182	142	75	85
Fairbanks	1	0	0	3	0	1	7	3	0	0
Delta	0	0	0	0	0	0	0	0	4	0
Tok	3	0	0	0	0	0	0	60	58	0
Copper R.	7	5	0	0	0	0	0	46	0	0
NORTHERN	11	5	0	3	0	1	7	109	62	0
TOTAL	**375**	**162**	**275**	**177**	**208**	**228**	**189**	**251**	**136**	**85**

Table II-5
Forest Practices Act – Road Miles Summary for State of Alaska, 2007-2014

Road Miles Notified	2007	2008	2009	2010	2011	2012	2013	2014
SSE	23	23	30	55	28	15	15	16
NSE	1	0	0	0	10	16	0.3	0
Mat-Su/SW	2	1	0	0	61	64	0	0
Kenai-Kodiak	24	16	3	66	0	0	6	44
COASTAL	50	40	33	122	99	95	21	60
Fairbanks	0	0	0	3	0	6	4	2
Delta	0	1	0	0	0	0	0	0
Tok	0	0	0	0	27	31	0	1
Copper R.	0	0	0	0	1	0	0	0
NORTHERN	0	1	0	3	28	37	4	3
TOTAL	**50**	**41**	**33**	**124**	**127**	**132**	**26**	**63**

Table II-6
State Timber Sales Sold

	Volume sold (MBF[1])		
Year	**North-Central**	**South-Central**	**Southeast**
1983	5,964	51,985	54
1984	14,735	4,445	1,907
1985	12,182	4,698	3,298
1986	4,450	2,587	424
1987	9,352	3,081	7,174
1988	16,510	4,513	6,452
1989	13,872.5	1,990	5,738
1990	14,317.9	3,398.8	18,064.5
1991	9,519	565	72.2
1992	20,613	3,306	186
1993	17,208	1,020	9,065
1994	1,569	5,564	8,903
1995	107,521	28,332	4,455
1996	182,131	9,368	1,109
FY97	15,528	129	5,942
FY98	13,211	17,754	14,623
FY99	6,836	2,803	4,797
FY00	6,637	5,774	8,365
FY01	6,064	1,857	954
FY02	4,207	1,333	11,340
FY03	4,813	3,779	4,094
FY04	2,708	957	8,064
FY05	5,594	4,934	16,003
FY06	12,478	6,638	10,777
FY07	6,420	30,110	24,437
FY08	7,163	4,316	4,059
FY09	11,036	1,451	5,597
FY10	5,445	2,460	4,626
FY11	7,281	3,913	12,865
FY12	8,815	11,067	1,346
FY13[2]	2,662	1,918	4,976
FY14	19,621	379	8,512

[1] Converted from Mcf.
[2] FY13 values are timber volume offered.
Note: data collection changed from calendar year (CY) to fiscal year (FY) with some overlap between 1996 and FY97.

Table II-7
FY 97 State Timber Sales Sold – Southeast

Area	Sale Name	Acres	Sale Date	Use	Vol MBF
Ketchikan	Ronald Brown	6	7/22/1996	local	37
Ketchikan	Pat Richter	4	8/21/1996	local	43
Ketchikan	Ernie Eads	9	8/22/1996	local	34
Ketchikan	Last Chance Enterprises	5	1/13/1997	local	55
Ketchikan	Ernie Eads	1	2/3/1997	local	8
Ketchikan	Pat Richter	1	3/3/1997	local	4
Ketchikan	Warren Jones	2	3/7/1997	local	46
Ketchikan	Norman Canaday	5	3/18/1997	local	14
Ketchikan	Ralph Porter	1	5/26/1997	local	34
Ketchikan	Daryl Tinkness	1	6/16/1997	local	19
Ketchikan	Ernie Eads	9	6/9/1997	local	228
Ketchikan	Pete Smit	8	5/30/1997	local	54
SUBTOTAL	**12**	**52**			**576**
Haines	Pond View	22	10/14/1996	local	249
SUBTOTAL	**1**	**22**			**249**
Juneau	Shadow	45	7/26/1996	Export	1,455
Juneau	Corner	12	9/30/1996	local	141
Juneau	Blackheart	14	11/7/1996	local	425
Juneau	Nufie	79	2/11/1997	local	1,700
Juneau	Thumb Nail	45	2/11/1997	local	802
Juneau	Pt. Frederick #6	9	3/7/1997	Export	446
Juneau	Silas Triangle	6	6/30/1997	mixed	106
Juneau	Magazine Road	3	6/30/1997	Export	42
SUBTOTAL	**8**	**213**			**5,117**

Table II-8
State Timber Sales Sold – FY 98 – Southeast

Area	Sale Name	Acres	Sale date	Use	Vol MBF
Ketchikan	Fleenor	5	7/25/1997	local	178
Ketchikan	Sneather	0	10/21/1997	local	7
Ketchikan	Whale pass assoc. I	0	11/3/1997	local	55
Ketchikan	Whale pass assoc. Ii	0	2/26/1998	local	67
Ketchikan	Tinkess	1	11/14/1997	local	5
Ketchikan	Trumble	1	11/24/1997	local	1
Ketchikan	Fleenor #2	8	3/6/1998	local	147
Ketchikan	Gray	1	12/8/1997	local	2
Ketchikan	Smith	3	PENDING	local	16
Ketchikan	Eads	2	5/12/1998	local	44
Ketchikan	Hammar	3	5/12/1998	local	21
Ketchikan	Hollis Comm. Council	0	5/12/1998	local	74
Ketchikan	Kitkun	160	6/29/1998	local	4,300
Subtotal	**13**	**184**			**4,917**
NSE	Thunder Creek	565	7/15/1997	export	4,331
NSE	Buster Benson	7	8/18/1997	local	80
NSE	Highline	8	9/2/1997	local	244
NSE	Alaska Power & Tele.	0	9/18/1997	local	6
NSE	Fred Strong	4	10/9/1997	local	32
NSE	Scott Rossman	5	5/8/1998	local	23
NSE	Scott Rossman #2	2	5/28/1998	local	12
NSE	Scott Rossman #3	2	6/15/1998	local	58
NSE	Banana Pt. Salvage	2	7/9/1997	local	40
NSE	Roy's Breakdown	41	7/23/1997	local	1,339
NSE	Silas	14	7/23/1997	local	466
NSE	Roy Sokol Salvage	1	7/29/1997	local	9
NSE	Thumbnail Unit 3	2	9/12/1997	local	229
NSE	Thumbnail ii	29	9/15/1997	local	607
NSE	Mitkof Hwy Row	1	11/21/1997	local	16
NSE	Hemlock Salvage	0	11/21/1997	local	9
NSE	Shadow Salvage	0	11/24/1997	export	120
NSE	Hermit Creek	4	12/22/1997	local	102
NSE	Pt. Frederick #6	0	6/5/1998	local	58
NSE	Eastern Passage I	83	2/23/1998	local	1,681
NSE	Nufie II	19	6/9/1998	local	244
Subtotal	**21**	**788**			**9,706**

Table II-9
State Timber Sales Sold – FY 99 Coastal Region

Area	Sale Name	Acres	Sale Date	MBF	Use
Ketchikan	Fleenor No. 3	6	07/27/98	125	Local
Ketchikan	Small #2	4	08/17/98	123	Local
Ketchikan	Small #3	3	09/28/98	68	Local
Ketchikan	Small #4	6	11/30/98	382	Local
Ketchikan	Small #5	4	11/30/98	308	Local
Ketchikan	Small #6	1	11/24/98	18	Local
Ketchikan	Small #7	3	12/11/98	80	Local
Ketchikan	Small #8	3	12/24/98	67.7	Local
Ketchikan	Small #9	0.1	03/26/99	10	Local
Ketchikan	Small #10	9.9	05/19/99	357	Local
Ketchikan	Small #11	4.7	06/01/99	150	Local
Subtotal	**11**	**44.7**		**1,688.7**	
NSE	Thumbnail III	74	09/21/98	1,613	Local
NSE	Eastern Passage I	52	06/01/99	1,429	Local
NSE	McCormack Creek Rd. Project ROW	0	08/03/98	37.25	Local
NSE	Del Mikkelsen	5	12/03/98	29	Local
Subtotal	**5**	**131**		**3,108**	

Table II-10
State Timber Sales Sold – FY 00 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Mcf	Use
Ketchikan	SE-959K	1	07/13/99	3		Local
Ketchikan	Coffman Cove	214	07/27/99	5,515		Local
Ketchikan	SE-960K	1	09/21/99	14		Local
Ketchikan	SE-962K	5	09/21/99	117		Local
Ketchikan	SE-1019K	1	03/13/00	12		Local
Ketchikan	SE-1021K	5	04/07/00	491		Local
Ketchikan	SE-970K	2	05/22/00	27		Local
Ketchikan	SE-971K	1	06/08/00	8		Local
Ketchikan	SE-1020K	1		34		Local
Ketchikan	SE-972K	5		468		Local
Ketchikan	SE-973K	8		257		Local
Subtotal	**11**	**244**		**6,945.9**		
NSE	Small #1, SE-474J	3	07/19/99	139		Local
NSE	Eastern Passage I, Unit 4	24	12/30/99	656		Local
NSE	Devils Elbow	2	07/19/99	24		Local
NSE	Porcupine Snow		12/22/99	41		Local
NSE	High Extension	8	02/01/00	49		Local
NSE	Porcupine Wings	24	03/28/00	419		Any
NSE	Porcupine Heights	5	04/05/00	38		Local
NSE	Roy's Favorite	3	06/02/00	53		Local
Subtotal	**8**	**69**		**1,419**		

Table II-11
State Timber Sales Sold – FY 01 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Purchaser	Use
SSE	SE-979-K	1	01/12/01	20	Jack Dupertuis	local
SSE	SE-983-K	2	03/14/01	28	Sealaska	export
SSE	SE-1020-K	2	10/16/00	34	Naukati Adventures	local
SSE	SE-976-K	7	10/03/00	391	Pat Richter	local
SSE	SE-980-K	0	12/08/00	10	Evergreen Timber	export
SSE	SE-981-K	2	12/08/00	30	Hummer Enterprises	local
SSE	SE-982-K	4	05/16/01	80	B&W Lumber	local
SSE	SE-984-K	0	05/17/01	10	Hummer Enterprises	local
Subtotal	**8**	**17**		**603**		
NSE	Ski Hill	5	07/29/00	34	The Stump Co.	local
NSE	37Mile	6	04/10/01	104	The Stump Co.	local
NSE	Chilkat Lake	2	04/10/01	19	Bob Jensen	local
NSE	Knob 4	2	04/10/01	28	Tophat Logging	local
NSE	Birch Hill	1	04/30/01	9	Eager Beaver	local
NSE	Knob Extension	1	06/18/01	1	Sage Thomas	local
NSE	Knobs Backside	5	06/25/01	24	Carl Smith	local
NSE	Half Load	1	01/18/01	11	Hidden Valley	local
NSE	Knob 3 Extension	2	02/05/01	16	Green Diamond	local
NSE	Daisy	3	02/23/01	65	Hidden Valley	local
NSE	SE-741	1	02/26/01	11	Don Peterson	local
NSE	Three Peaks	2	03/12/01	20	Green Diamond	local
NSE	Knob ABC	2	03/21/01	9	Green Diamond	local
Subtotal	**13**	**33**		**351**		

Table II-12
State Timber Sales – FY 02 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Use
SSE	Naukati West	70	04/29/02	2,685	V-A
SSE	East Pass #5	50	04/01/02	1,110	V-A
SSE	Tuxecan	134	04/15/02	4,018	V-A
SSE	Richter #2	4	07/09/01	187	V-A
SSE	Richter #3	3	02/08/02	90	V-A
SSE	Jones 1	0	09/18/01	13	V-A
SSE	Sunde 1	0	05/30/02	7	V-A
SSE	Clark Bay Group	3	11/02/01	26	V-A
SSE	Gildersleeve1	1	09/17/01	24	V-A
SSE	Thorne Bay #1	80	09/14/01	2,539	V-A
Subtotal	**10**	**345**		**10,699**	
NSE	37.5 Mile Fall	4	10/25/01	51	V-A
NSE	37-Mile Addition	4	07/24/01	28	V-A
NSE	Daisy Salvage	1	10/16/01	31	V-A
NSE	Birch Road A	2	07/13/01	17	V-A
NSE	Birch Pole	1	01/08/02	3	V-A
NSE	Backside 2	3	07/10/01	19	V-A
NSE	Daisy 2	7	05/24/02	117	V-A
NSE	Birch road	2	07/06/01	10	V-A
NSE	Daisy Dead	2	06/06/02	9	V-A
NSE	LS Mountain	10	07/09/01	357	V-A
Subtotal	**10**	**36**		**641**	

Table II-13
State Timber Sales Sold – FY 03 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Use
SSE	Yatuk Creek #1	4	10/15/02	179	VA
SSE	Yatuk Creek #2	5	10/15/02	228	VA
SSE	Yatuk Creek #3	2	10/15/02	80	VA
SSE	Yatuk Creek #4	4	10/15/02	41	VA
SSE	Yatuk Creek #5	6	10/15/02	205	VA
SSE	Yatuk Creek #6	4	10/15/02	112	VA
SSE	Yatuk Creek #7	4	10/15/02	308	VA
SSE	Yatuk Creek #8	3	10/15/02	151	VA
SSE	Yatuk Creek #9	64	01/06/03	2,064	VA
SSE	Frederick Rd. #1	4	10/14/02	125	VA
SSE	Thorne Bay Burn #4	2	11/01/02	53	VA
SSE	Thorne Bay Burn #5	2	11/01/02	40	VA
SSE	Sandy Road #1	6	11/01/02	87	VA
SSE	Sunde #2	<1	05/06/03	10	VA
Subtotal	**14**	**110**		**3,683**	
NSE	Starigavin ROW NSE-1026	1	09/27/02	6	VA
NSE	Tidy Stump SE-759	1	08/23/02	25	VA
NSE	Farm Wood	3	01/17/03	50	VA
NSE	Jensen Skid Road	3	02/18/03	19	VA
NSE	Hemlock Switch	5	02/10/03	67	VA
NSE	Spruce Addition	1	02/04/03	10	VA
NSE	20 Mile Xing	2	02/26/03	13	VA
NSE	Half Dozen	1	02/28/03	4	VA
NSE	Wolf Pack	1	03/10/03	13	VA
NSE	Chilkat Lake Road	2	03/27/03	5	VA
NSE	Spruce Log	2	01/03/03	10	VA
NSE	Hemlock Home	1	01/13/00	13	VA
NSE	Porcupine Clean	1	11/04/02	11	VA
NSE	Farm Birch	2	12/17/02	6	VA
NSE	Wolf Skid	2	04/04/03	4	VA
NSE	Spruce Tap	2	05/05/03	7	VA
NSE	Hemlock Corner	2	05/05/03	41	VA
NSE	37 Mile Patch	1	05/19/03	10	VA
NSE	38 Mile Draw	9	05/21/03	84	VA
NSE	Daisy Cleanup	3	06/13/03	64	VA
Subtotal	**20**	**45**		**462**	

Table II-14
State Timber Sales Sold – FY 04 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Use
SSE	Boy Scout	19	08/21/03	990.18	local
SSE	Intertie ROW	n/a	07/21/03	172.00	local
SSE	Coffman Cove R	1	08/18/03	40.40	local
SSE	Kasaan 1	149	10/21/03	3,238.00	local
SSE	East Naukati	135	05/06/04	3,164.00	local
SSE	Thorne Bay ROW	1	12/12/03	42.43	export
Subtotal	**6**	**305**		**7,647.01**	
NSE	Deats 1-N. Douglas	1	03/14/04	1.00	local
NSE	Little Salmon Mt.	8	10/03/03	357.00	local
NSE	38-mile Draw 5	1	10/02/03	10.00	local
NSE	Spruce Rose	1	07/08/04	11.00	local
NSE	Big Hemlock	2	07/23/03	34.00	local
NSE	Boulder Spruce	3	08/10/03	52.00	local
NSE	Boulder Spruce 2	10	10/30/03	24.00	local
NSE	38 Mile Pocket	1	11/25/03	33.00	local
NSE	Stretch Time	2	12/10/03	29.00	local
NSE	Ice Road	2	02/06/04	28.00	local
NSE	Boulder 6 x 6	1	05/03/04	21.00	local
NSE	Stretch Melt	2	06/10/04	31.00	local
NSE	Nataga Skid	3	06/10/04	5.24	local
NSE	Stretch	6	11/28/03	53.00	local
NSE	38 Mile Extension	1	12/09/03	22.00	local
Subtotal	**15**	**44**		**711.24**	

Table II-15
State Timber Sales Sold – FY 05 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Use
SSE	2058 Road 1/Jones #2	3	07/09/04	36	local
SSE	2058 Road 2/Jones #3	2	07/09/04	28	local
SSE	2058 Road 4/Jones #1	2	07/09/04	19	local
SSE	2058 Road 5/Thorne Bay WP	6	07/27/04	107	local
SSE	2058 Road 6/Thorne Bay WP	3	07/21/04	65	local
SSE	Sandy Road 2	20	08/20/04	419	local
SSE	Coffman Cove ROW #2	1	08/23/04	8	local
SSE	Thorne Bay 2	130	10/30/04	4130	local
SSE	Control Lake 1-mid	112	11/15/04	3627	local
SSE	Shady Tie-in	40	11/29/2004	987	local
SSE	Kasaan 6	6	11/17/04	179	local
SSE	Control Lake 2	5	12/03/04	121	local
SSE	Control L. 3	8	12/03/04	189	local
SSE	Control L. 4	17	12/09/04	491	local
SSE	Kasaan 2	108	12/17/04	4028	local
SSE	Mt. Point #1	3	05/12/05	149	export
SSE	Choker Setter Cir.	1	06/28/05	23	local
Subtotal	**17**	**466**		**14,606**	
NSE	Boulder Load	1	7/6/2004	8	local
NSE	Boulder Six X Six 2	1	7/12/2004	8	local
NSE	Alder Rerun	2	7/23/2004	27	local
NSE	Alder Rerun 2	2	9/1/2004	41	local
NSE	Nataga Skid 2	1	8/12/2004	17	local
NSE	Alder III	2	9/17/2004	59	local
NSE	Porcupine Mining	1	9/10/2004	20	local
NSE	Porcupine Mining II	1	9/10/2004	23	local
NSE	Klehini U14 Corner	2	12/11/2004	32	local
NSE	Porcupine Mining III	1	10/15/2004	13	local
NSE	Takshanuk Trail	3	11/7/2004	14	local
NSE	37 Mile Ridge	2	11/11/2004	15	local
NSE	Porcupine Low Road	1	11/12/2004	10	local
NSE	Battleship Island	1	12/12/04	2	local
NSE	West Herman 2	9	1/3/2005	185	local
NSE	37 Mile Bowl	2	1/4/2005	27	local
NSE	37 Mile Bowl 2	1	1/24/2005	38	local
NSE	Purlin	1	02/16/05	1	local
NSE	Pondside	2	02/28/05	31	local
NSE	West Draw	2	03/14/05	21	local
NSE	West Herman 1	23	03/01/05	594	local
NSE	West Draw #2	1	04/01/05	21	local
NSE	Knobs Rerun	2	05/21/05	49	local
NSE	Fabrizio Mining	6	05/27/05	82	local
NSE	Birch Reload	1	05/18/05	6	local
NSE	Nataga Sky	1	06/10/05	22	local
NSE	Dunit Bench	2	06/20/05	31	local
Subtotal	**27**	**74**		**1,397**	

Table II-16
State Timber Sales Sold – FY 06 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Use
SSE	2058 Rd 8 small/Gutchi Creek #2	5	08/02/05	108	local
SSE	SSE 1230/2058 Rd 8 mid	18	10/01/05	588	local
SSE	Eastern Passage units 6-12	395	11/01/05	9110	local
SSE	Steep Drive	1	10/19/05	20	local
SSE	South Thorne Arm #1	0	10/01/05	2	local
SSE	Leask Lake Sort Yard	5	09/22/05	60	export
SSE	Kasaan 6	6	3/28/2006	179	local
Subtotal	**7**	**430**		**10,067**	
NSE	Tatshunak Trail	1	8/2/2005	5	local
NSE	Knobs B-C Timber	1	7/25/2005	16	local
NSE	Nataga Stretch	18	7/25/2005	173	local
NSE	Glacier Salvage	10	10/1/2005	100	local
NSE	Spruce Corner	1	10/3/2005	27	local
NSE	KB West Spur 1	10	10/10/2005	144	local
NSE	1424 Hemlock Ridge	1	12/29/2005	46	local
NSE	1425 Porcupine Salvage	3	1/6/2006	25	local
NSE	1426 Billy Goat	3	1/6/2006	24	local
NSE	1427 Farm Special	5	2/1/2006	38	local
NSE	1428 Farm Spur 2	3	03/15/06	37	local
NSE	1429 Billy Goat 2	3	04/11/06	55	local
NSE	Boulder Firewood	1	04/11/06	10	local
NSE	Porcupine Firewood	2	06/26/06	10	local
Subtotal	**14**	**62**		**710**	

Table II-17
State Timber Sales Sold – FY 07 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Use
SSE	Bostwick #1	362	11/29/06	12,687	local
SSE	2058 Road Small	6	07/10/06	182	local
SSE	2058 Road Small	4	07/10/06	98	local
SSE	Control Lake Fir	1	08/25/06	0	local
SSE	Leask Lake Aide	1	08/25/06	19	research
SSE	South Thorne Bay	128	07/02/06	3,330	local
SSE	D-1 #1	1	04/02/07	7	export
SSE	20 Road	26	05/29/07	5,145	local
SSE	Whipple Creek	26	04/02/07	2,334	export
SSE	Bostwick Trail Lo	0	6/20/2007	13	local
Subtotal	**10**	**555**		**23,815**	
NSE	KB2	1	7/28/2006	17	local
NSE	Cabin Log	4	8/10/2006	41	local
NSE	Spur Road	1	8/10/2006	12	local
NSE	West Herman 3	4	8/25/2006	105	local
NSE	Porcupine Spruce	3	9/12/2006	132	local
NSE	Hemlock Spruce	3	9/12/2006	55	local
NSE	KB3	6	10/26/2006	42	local
NSE	Winds	2	11/2/2006	119	local
NSE	Porucpine Road	1	11/7/2006	5	local
NSE	Warm Springs	5	10/01/06	1	local
NSE	Hidden	2	01/03/07	16	local
NSE	35 Mile Snow Co	10	04/09/07	9	local
NSE	Sunlight Salvage	2	05/11/07	45	local
NSE	Ski Hill	3	06/05/07	23	local
Subtotal	**14**	**47**		**622**	

Table II-18
State Timber Sales Sold – FY 08 through 14 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Product
	Fiscal Year 2008				
SSE	Java	44	12/14/2007	1,325	Sawlog
SSE	Gutchi Creek	24	12/14/2007	34	Sawlog
SSE	Squirrel	72	04/07/2008	-	Sawlog
SSE	Kasaan Small Sale #2	5	04/16/2008	26	Sawlog
SSE	Kasaan Small Sale #3	6	04/16/2008	8	Utility
SSE	Indian Creek	72	07/14/2008	111	Sawlog
SSE	Limestone Place	1	07/14/2008	0.4	Sawlog
SSE	Mountain Pt. #2	2	08/13/2008	14	Sawlog
SSE	Jinhi Bay	10	08/13/2008	54	Utility
SSE	Kasaan Small Sale	5	09/17/2008	4	Utility
Subtotal	**10**	**241**		**1,576**	
NSE	Old Highway 3	4	10/24/2007	21	Sawlog
NSE	Revetment	3	01/18/2008	10	Sawlog
NSE	Old Highway #4	2	04/16/2008	1	Utility
NSE	Old Highway #5	2	05/09/2008	16	Sawlog
NSE	Sunshine LSM Salvage	2	07/15/2008	100	Utility
NSE	KB 6	14	07/21/2008	12	House Log
NSE	Billy Goat Cleanup	2	08/06/2008	29	Sawlog
NSE	Roads End	5	08/14/2008	95	Utility
NSE	West Herman 4	5	09/04/2008	50	Sawlog
NSE	Glacier Side Salvage	9	09/15/2008	100	Sawlog
NSE	KB Firewood	8	09/25/2008	2	Utility
Subtotal	**11**	**52**		**436**	
	Fiscal Year 2009				
SSE	Squirrel Export	15	01/06/2009	137	Sawlog
SSE	Kasaan #2 Export	10	02/17/2009	105	Sawlog
SSE	Jinhi Bay Export	-	02/17/2009	93	Sawlog
SSE	Java Export	-	02/18/2009	0.2	Sawlog
SSE	20 Road Export	-	02/18/2009	47	Sawlog
SSE	S.Thorne Bay #1 Export	-	03/04/2009	4	Sawlog
SSE	Heceta #2	1	04/02/2009	1	Sawlog
SSE	S. Thorne Bay #2	107	06/10/2009	2,149	Sawlog
SSE	Indian Creek - Export	-	07/02/2009	185	Sawlog
Subtotal	**9**	**133**		**2,720**	
NSE	Gustavus Gravel FC	1	10/20/2008	8	Sawlog
NSE	Big Spruce	1	03/03/2009	3	Sawlog
NSE	KB-7	10	07/02/2009	25	Sawlog
NSE	Jim Nail Mining Claim	2	08/15/2009	5	House Log
NSE	Porcupine Bear II	-	09/02/2009	13	Sawlog
Subtotal	**5**	**14**		**54**	

Table II-18
State Timber Sales Sold – FY 08 through 14 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Product
	Fiscal Year 2010				
SSE	Kasaan #7 Export	1	11/07/2009	18	Sawlog
SSE	Zarembo	175	12/17/2009	1,803	Sawlog
SSE	Kasaan Closout	21	04/26/2010	22	Utility
SSE	S. Thorne Bay #2 Export	-	04/26/2010	242	Sawlog
SSE	Bradford Yellow Cedar	-	08/05/2010	3	Sawlog
SSE	Acorn	5	09/22/2010	73	Sawlog
Subtotal	**6**	**202**		**2,161**	
NSE	Glacier Creek Rd Salvage	5	10/02/2009	100	Utility
NSE	Elbow	5	10/20/2009	100	Utility
NSE	Porcupine Bear III	2	10/25/2009	2	Sawlog
NSE	Flower	5	10/25/2009	100	Utility
NSE	State 38	3	12/09/2009	12	Sawlog
NSE	38 Mile South	3	04/28/2010	2	House Log
NSE	35 Times	2	07/15/2010	10	Utility
NSE	West Herman Cleanup	1	07/15/2010	5	Utility
Subtotal	**8**	**26**		**331**	
	Fiscal Year 2011				
SSE	D1 #2	7	02/01/2011	9	Utility
SSE	D1 Heli-Dup1	8	02/17/2011	353	Sawlog
SSE	D1 Heli-Dupe2	8	02/18/2011	360	Sawlog
SSE	R/W Spruce Log	-	03/18/2011	4	Sawlog
SSE	North Thorne Bay #3	122	04/22/2011	3,063	Sawlog
SSE	Indian Creek #2	230	06/21/2011	11	Sawlog
SSE	East Pass Units 9-12	194	08/28/2011	250	Sawlog
Subtotal	**7**	**569**		**4,050**	
NSE	39 Mile ROW	2	11/17/2010	9	House Log
NSE	37.5 Salvage	5	12/17/2010	50	Utility
NSE	North 38	1	03/25/2011	3	House Log
NSE	Bear Creek	2	05/13/2011	10	House Log
NSE	Billy Goat Clean Up #2	1	06/13/2011	40	Utility
NSE	Assisted Migration	4	06/17/2011	19	Sawlog
NSE	Billy Goat Cleanup #3	1	06/27/2011	1	House Log
NSE	Bear Creek 2	3	07/07/2011	13	Utility
NSE	Jim Nail Salvage	1	07/18/2011	50	Utility
NSE	Bear Creek SMZ	1	07/20/2011	11	Sawlog
NSE	35 Times 2	2	07/21/2011	10	Sawlog
NSE	Bear Creek SMZ 2	1	08/08/2011	1	Sawlog
Subtotal	**12**	**24**		**217**	

Table II-18
State Timber Sales Sold – FY 08 through 14 – Southeast

Area	Sale Name	Acres	Sale Date	MBF	Product
	Fiscal Year 2012				
SSE	Chopsticks	-	10/14/2011	4	Sawlog
SSE	Blind Slough Salvage	1	01/30/2012	2	Sawlog
SSE	Beach Road #1	23	05/07/2012	191	Sawlog
Subtotal	**3**	**24**		**197**	
NSE	38 Mile Salvage	4	02/07/2012	100	Utility
NSE	37 Mile Creek	9	03/30/2012	4	Sawlog
NSE	KB7 Leftovers	3	07/03/2012	12	House Log
NSE	35 x 3	2	08/13/2012	5	Sawlog
NSE	Houselog Bonanza	3	08/22/2012	4	Sawlog
NSE	211 Road Salvage	3	08/24/2012	30	Fuel Wood
NSE	Windthrown	3	08/28/2012	6	Sawlog
Subtotal	**7**	**27**		**161**	
	Fiscal Year 2013				
SSE	S. Thorne Bay #3	196	11/17/2012	30	Sawlog
SSE	Whitman Lake Penstock	1	02/12/2013	0.2	Sawlog
SSE	Colier Tree	1	03/13/2013	8	Sawlog
SSE	Heceta Second Growth	137	07/22/2013	301	Utility
Subtotal	**4**	**335**		**339**	
NSE	Hemlock Revetment	3	10/08/2012	32	Sawlog
NSE	13 Mile Bench #2	3	02/22/2013	2	Utility
NSE	13 Mile Bench #2 Addition	1	03/14/2013	1	Sawlog
NSE	KB9	3	06/04/2013	7	House Log
NSE	KB 10	2	07/15/2013	19	Sawlog
NSE	Tenekee Hydro	4	09/09/2013	55	Sawlog
Subtotal	**6**	**16**		**116**	
	Fiscal Year 2014				
SSE	Whitman Lake Penstock #2	0.1	02/21/2014	2	Sawlog
SSE	Control Lake Timber Sale	10	02/28/2014	46	Sawlog
SSE	Hollis Slide USFS Wood	-	03/06/2014	4	Unknown
SSE	Blankenship ROW	-	03/11/2014	4	Sawlog
SSE	South Thorne Bay 4	98	03/12/2014	35	Sawlog
SSE	Naukati Decks	-	06/10/2014	2	Sawlog
Subtotal	**6**	**108**		**93**	
NSE	13 Mile Bench #5	1	02/12/2014	26	House Log
NSE	13 MIle Bench #6	1	03/14/2014	1	Sawlog
NSE	13 Mile Bench Birch	1	03/19/2014	2	Sawlog
NSE	KB14	5	07/15/2014	25	Utility
Subtotal	**4**	**8**		**54**	

APPENDIX D
EVALUATION AND INTEGRITY OF THE TONGASS NATIONAL FOREST OLD-GROWTH HABITAT CONSERVATION STRATEGY

Appendix D

Tongass National Forest

Evaluating Integrity of the Tongass National Forest Old-growth Habitat Conservation Strategy

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Introduction

This appendix provides an overview of the rationale and assumptions used for evaluating proposed changes to the 2008 Tongass Land and Resource Management Plan (2008 Forest Plan) in relation to the Tongass Old-growth Habitat Conservation Strategy (conservation strategy). The conservation strategy, built from current conservation science, provides for an ecological approach to conservation of old-growth forest and associated species in the Forest Plan, and consists of a system of old-growth reserves (OGRs) and management restrictions on matrix lands (non-reserve areas). Riparian, beach, and estuary habitats are considered contributing elements to the OGR component of the strategy in that they were designed to maintain landscape connectivity among large and medium OGRs and non-development LUD designations. An intensive scientific evaluation of the Conservation Strategy and species-specific viability assessments were included in the 1997 Forest Plan planning efforts (USDA Forest Service 1997b, Appendix N). This appendix builds on Appendix N of the 1997 Forest Plan and considers Appendix N a foundation and primary reference for the science behind the conservation strategy.

On May 27, 2014, the Tongass National Forest initiated an amendment designed to transition from timber harvest dominated by old-growth to young-growth over the next 10 to 15 years (79 FR 30075). The need for change comes from a July 2013 memo from U. S. Department of Agriculture Secretary Tom Vilsack (Secretary's Memorandum 1044-009). In this memo, the Secretary directs the Tongass to transition its forest management program to be more ecologically, socially, and economically sustainable by transitioning to young-growth harvest at the end of this 10 to 15 year period.

In response, the Forest Service is proposing to amend the 2008 Forest Plan and prepared this Environmental Impact Statement (EIS) to evaluate the proposed changes. Five alternatives were developed for detailed analysis, including the No Action (Alternative 1). Alternative 1 represents current management (i.e., the 2008 Forest Plan). Alternatives 2, 3, 4, and 5 (the Preferred Alternative) were designed to accomplish a more rapid transition to young-growth management than considered in the 2008 Forest Plan, while maintaining a viable timber industry in Southeast Alaska. The alternatives vary in how quickly the transition is reached, with some alternatives allowing young-growth harvest in non-development LUDs and modifying other contributing elements of the conservation strategy to accomplish the transition in a shorter time frame than the current Forest Plan. Alternative 5 is the proposed Forest Plan, and the Preferred Alternative. It was developed by the Tongass Advisory Committee, a FACA committee. Each of these alternatives is described in detail below.

New direction in the proposed Forest Plan was developed to facilitate this transition including the identification of lands suitable for timber production employing young-growth management. Under some alternatives, young-growth stands in the beach buffer and in RMAs outside of Tongass Timber Reform Act (TTRA) buffers or in non-development LUDs are considered suitable for timber production. The Forest Service has the dual responsibility of ensuring that the transition to young-growth management maintains a viable timber industry, while also maintaining the integrity of the conservation strategy. Other recent occurrences which affect the conservation strategy include the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015 (hereafter referred to as the National Defense Authorization Act for Fiscal Year 2015) and changes in the 2001 Roadless Rule. These factors, which are outside of the authority of the Forest Service, are also described below.

The remainder of this appendix is broken into five major sections. They (1) provide an overview of the current conservation strategy (2) describe the scope of the analysis and discuss new science relevant to the conservation strategy since 2008, (3) summarize the status of land management on the Tongass and changes to the conservation strategy since 2008, (4) describe proposed modifications to contributing elements of the conservation strategy and evaluate these modifications in the context of maintaining a functioning conservation strategy, and (5) present a summary of the findings of this evaluation which can be used to support the analysis of effects to biodiversity and wildlife presented in Chapter 3 of the EIS.

Appendix D

Old-growth Habitat Conservation Strategy

The conservation strategy was designed to maintain the integrity of the old-growth forest ecosystem (see USDA Forest Service 1997b, Appendix N pp. N-20 to N-24). This appendix presents the results of an evaluation of the ability of each of the alternatives analyzed in the EIS to maintain the integrity of the conservation strategy. Integrity is defined here based on standard language as 'an unimpaired condition' or "the quality or state of being complete or undivided" (http://www.merriam-webster.com/dictionary/integrity). It is assumed that integrity is maintained when the conservation strategy is expected to continue to function effectively regardless of alteration or modification of individual parts, that is, its functioning as a whole remains unimpaired. Accordingly, throughout this evaluation, focus is placed on the proposed modifications to any contributing elements of the conservation strategy, such as the beach and estuary fringe and RMAs, and the associated potential to affect the functioning of the conservation strategy.

The 1997 Tongass National Forest Plan established a comprehensive, science-based conservation strategy to provide for wildlife sustainability and viability across the Tongass. The conservation strategy was developed to maintain a functional and interconnected old-growth forest ecosystem on the Tongass by retaining intact, largely undisturbed habitat. In doing so, it was also intended to "[P]rovide sufficient habitat to preclude the need for listing of species under the Endangered Species Act, or from becoming listed as Sensitive due to National Forest habitat conditions" (USDA Forest Service 1997c, p.34). Its development is described in detail in Appendix N of the 1997 Forest Plan FEIS (USDA Forest Service 1997a, 1997b) which is the foundation for this current analysis and will not be cited repeatedly but is incorporated throughout by reference. The conservation strategy was subsequently reviewed to confirm its validity given any new conservation science since 1997 and the proposed changes to the Old-growth Habitat LUD and amended for incorporation into the 2008 Forest Plan (USDA Forest Service 2008a, 2008b; see below for additional discussion).

The conservation strategy includes two major components: (1) a forest-wide network of large, medium and small OGRs allocated to the Old-Growth Habitat LUD and other non-Development LUDs plus all islands less than 1,000 acres, and (2) a series of standards and guidelines applicable to lands where timber harvest is permitted (the matrix; USDA Forest Service 2008a, 2008b).

The system of OGRs was designed to maintain habitats of the species that have the most viability concerns (USDA Forest Service 2008b). Other forested non-development LUDs such as Wilderness, LUD II, Remote Recreation, and Semi-Remote Recreation contribute in a substantial way to the old-growth ecosystem. The intent of the reserve system was to ensure the maintenance of well-distributed, viable populations of all old-growth associated wildlife species across the Tongass, with focus on those species that are most sensitive to habitat loss and fragmentation. In general, the home range and dispersal capabilities of old-growth associated species were considered in determining the size, number and spacing of reserves. For the most recent complete review of the Forest Plan Conservation Strategy, including assumptions underlying the design of the OGR system, refer to Appendix D of the 2008 Forest Plan Final EIS (USDA Forest Service 2008b).

Within the matrix (areas outside of reserves), components of the old-growth ecosystem are maintained through standards and guidelines designed to provide for important ecological functions such as dispersal of organisms, movement between forest stands, and maintenance of ecologically valuable structural components such as down logs, snags, and large trees (USDA Forest Service 2008b). Matrix lands include Timber Production, Modified Landscape, and Scenic Viewshed, LUDs. Matrix management complements the reserve system by providing habitat at finer spatial scales, enhancing the effectiveness of reserves, and providing for landscape connectivity (USDA Forest Service 2008b). Standards and guidelines applicable to these lands include the 1,000-foot beach and estuary fringe, variable-width stream buffers (Riparian Management Areas (RMAs), TTRA buffers, etc.), project-level legacy old-growth forest structure retention requirements, and species specific standards and guidelines. In addition, other Forest-wide standards and guidelines preclude or limit timber harvest in areas of high-hazard soils, steep slopes, karst terrain, and visually sensitive travel routes and use areas, and require projects to be designed to maintain landscape connectivity (i.e., maintain corridors of forest among large and medium OGRs and other non-development LUDs at broad spatial scales). Additional detail on the rationale

behind the standards and guidelines within the matrix is provided in Appendix D of the 2008 Forest Plan FEIS (USDA Forest Service 2008b).

Young-growth forest stands within the matrix and within reserves have ecological values which contribute to the functioning of the reserve system. However, at the time of its development in 1997 it was assumed that the conservation strategy would maintain a functional and interconnected old-growth forest ecosystem without the additional contribution of previously harvested areas, either as young-growth or over time as these stands matured to old-growth condition. That is, it was designed acknowledging the consequences of past harvest and harvest proposed under the 1997 Forest Plan to ensure that an adequate amount of old-growth forest was protected within the planning area to maintain a functional and interconnected old-growth forest ecosystem, capable of supporting viable, well-distributed wildlife populations.

The 1982 Planning Rule stated that the maintenance of a viable population requires providing habitat to support "at least a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area" (36 CFR 219.19). In the context of the development of the conservation strategy, this was interpreted to mean that the condition of viable and well distributed allows for gaps within a species distribution as long as the population segments of the species continue to interact and are distributed throughout the planning area. (Appendix N (p. N-3), USDA FS 1997). The 2012 Planning Rule now requires that the responsible official determine whether or not the plan components ''provide the ecological conditions necessary to contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern within the plan area" (36 CFR 219.9). The 2012 Planning Rule defines a viable population as: ''A population of a species that continues to persist over the long-term with *sufficient distribution to be resilient and adaptable to* stressors and likely future environments'' (§ 219.19) (emphasis added). Therefore, the ability of the conservation strategy to function as intended can be gauged on the scale of the Forest and beyond; however, it is acknowledged that some portions of the Forest may be better meeting the intent of the conservation strategy than others. It should be noted that the wildlife components of the Forest Plan remain under the 1982 Planning Rule, and specific updates to meet 2012 Planning Rule requirements are not proposed under this Forest Plan Amendment.

Scope of the Analysis and Acknowledgement of New Science

The scope of this analysis is the individual proposed modifications to the contributing elements of the conservation strategy and the associated potential to affect its functioning. The proposed Forest Plan amendment does not propose changes to the framework of the conservation strategy or the size or spacing of OGRs except for adjustments due to the National Defense Authorization Act for Fiscal Year 2015. The proposed OGR modifications compensate for portions of individual OGRs that were located on National Forest System (NFS) lands that were conveyed to the Sealaska Native Corporation (see below). Therefore, this analysis is not a review of the underpinnings of the current conservation strategy. .

Recent advancements in the fields of conservation science and landscape ecology and new knowledge of individual species' biological needs is included in the following discussion. Some of these topics and others (described below) were identified during the original development of the conservation strategy for the 1997 Forest Plan and considered again during the Interagency Forest Plan Conservation Strategy Review (USDA Forest Service 2007) conducted for the 2008 Forest Plan Amendment (see *New Relevant Science Since 1997* in Appendix D, USDA Forest Service 2008b). The following discussion touches on some of the new science related these topic areas relevant to conservation planning on the Tongass National Forest.

Recent research confirms the importance of including freshwater systems in conservation strategy design (Nislow et al. 2010). The Tongass National Forest supports some of the most productive salmon spawning habitats in North America and salmon-derived nutrients are recognized as playing an important role in the productivity of coastal temperate forests (Hood et al. 2007; Fellman et al. 2008, 2009, D'Amore et al. 2011). The strong connections between aquatic and terrestrial ecosystems, as well as upstream and downstream linkages within stream and river systems, are also susceptible to disruption by human

actions and are therefore important elements to be considered in conservation planning (Nislow et al. 2010). Aquatic systems and hydrologic connectivity are afforded protection by Forest Plan Riparian and Beach and Estuary standards and guidelines which were developed in part based on recommendations put forth in an Anadromous Fish Habitat Assessment (AFHA 1995). Best management practices for riparian and stream management, implemented at the project level, also provide protection to these resources.

The contribution to conservation by matrix lands, or areas where active land management can occur, is receiving even greater emphasis. Matrix lands are critical to maintaining the connectivity of ecological flows across a landscape (e.g., flows of disturbance agents, organisms, water, and nutrients) and are also essential to the ability of protected areas to achieve their mandates for ecosystem conservation (Schmiegelow et al. 2006, Schmiegelow and Lisgo 2014). Conservation focused on the management of matrix lands is referred to as the reverse-matrix model of conservation design. Under this paradigm, the concept of habitat reserves as nodes of conservation land within a largely degraded environment is inverted, such that conservation lands are, in fact, the matrix within which development activities are carefully managed so as not to erode other values (Schmiegelow et al. 2006). More intensive activities would occur on “islands” within the sea of conservation land (Schmiegelow et al. 2006). Schmiegelow et al. (2006) identify four contributions of matrix lands to conservation goals including supporting populations of species, regulating the movement of organisms, buffering sensitive areas and reserves, and maintaining the integrity of aquatic systems. Thus, the ability to achieve conservation goals is clearly dependent in part on the management of activities within matrix lands.

The Tongass conservation strategy is a reserve-based design, recognizing different functions of the reserve system and matrix lands. Ecological values within the matrix are protected by standards and guidelines, such as the beach and estuary fringe and riparian buffers, which provide physical connectivity via protected forested corridors. Matrix lands are also protected by standards and guidelines implemented at the project-level which contribute to functional connectivity through the additional retention of old-growth forest in areas where timber harvest is restricted including areas of high-hazard soils, steep slopes, karst terrain, and visually sensitive travel routes and use areas (USDA Forest Service 1997c, p.32). However, the ecological functions of most upland young-growth stands were largely unacknowledged in the development of the conservation strategy except where they contributed to the beach and estuary fringe and riparian buffers.

Young-growth stands can provide a range of functions including serving as dispersal corridors between old-growth stands as well as providing buffers between areas of suitable habitat and human activity (e.g., buffering forests from edge effects). Although immediately after harvest and until they become more structurally complex, young-growth stands can create dispersal barriers for certain old-growth associated species, over time, young-growth stands have the potential to return to old-growth conditions, a process that can be accelerated through active management such as thinning. The Old-growth Habitat LUD standards and guidelines call for actions that would facilitate the transition to old-growth conditions. Similarly, Forest-wide standards and guidelines for landscape connectivity call for actions in young-growth stands to accelerate the development of old-growth characteristics in order to increase connectivity for wildlife and to provide higher quality habitat within the matrix lands. The transition to young-growth management under the proposed Forest Plan amendment has the potential to both positively and negatively affect the condition and quality of matrix lands, and thus their contribution to the conservation strategy. This topic is addressed below in the context of the proposed modifications to contributing elements of the conservation strategy.

Finally, the design of the original conservation strategy in 1997 was based in part on the needs of old-growth associated species (see Appendix N of the 1997 Forest Plan FEIS). In general, the home ranges and dispersal capabilities of these species were taken into account during the design of the reserve system, including reserve size, spacing, and number, as well as in the development of provisions for matrix management (USDA 1997b). Since 2008, there have been research publications that address some of these species including goshawks (Smith 2013), wolves (Person and Russell 2008, 2009; Weckworth et al. 2010, 2011; ADF&G 2012; Person and Logan 2012), brown bears (Flynn et al. 2009), marten (Flynn and Schumacher 2009, Pauli et al. 2015), deer (White et al. 2009) and flying squirrels

(Flaherty et al.2008, 2010; Pyare et al. 2010; Shanley et al. 2013; Smith 2012; Smith et al. 2011) which provide additional considerations regarding their conservation needs. Information from these studies, other relevant studies and other best available science would be used to review the conservation strategy design if, in the future, data from various sources suggest that the conservation strategy is no longer functioning as originally intended. However the results of the analysis in this appendix indicate the conservation strategy currently functions as intended and is expected to function regardless of which alternative is selected.

The conservation strategy was designed to maintain a resilient old-growth forest ecosystem in the face of uncertainty, including uncertainty associated with climate change. Climate change in Southeast Alaska may result in increased blowdown, increased tree mortality from insects and disease, increased fire frequency and severity, warmer temperatures and changes in precipitation patterns, and greater weather extremes (Haufler et al. 2010, Shanley et al. 2015). These effects are anticipated to result in changes to vegetation and thus, the suitability of wildlife habitats protected by the conservation strategy. Although the extent of changes in vegetation expected as a consequence of climate change is unknown, analysis on the neighboring Chugach National Forest suggests that the temperate coastal rainforest is expected to be resilient (see Hayward et al. *in prep*).

Current Status of Land Management on the Tongass

This section describes the land management activities that have altered the context within which the conservation strategy was designed. These include actual timber harvest levels, mapping updates that have resulted in a net increase in the amount of productive old-growth (POG) forest estimated on the Tongass, modifications to the conservation strategy since 2008, and Non-NFS land management decisions.

Projected Versus Actual Timber Harvest Levels

The design of the conservation strategy was intended to achieve multiple use objectives by allowing for activities such as timber harvest, recreation, and infrastructure development. Therefore, it was developed in the context of maintaining a robust timber harvest program over the life of the approved Forest Plan, while conserving old-growth forest and associated species. However, market conditions and other factors have resulted in harvest levels (in both spatial extent and volume) that are much lower than anticipated. Both the 1997 and 2008 Forest Plan EISs include projections of the amount of original productive old-growth (POG) forest[1] (existing in 1954 prior to large-scale timber harvest) remaining after 100 years (timber sale rotation) based on a decadal Allowable Sale Quantity (ASQ). The conservation strategy was based on an assumed harvest rate of about 83,400 acres per decade. If harvest took place at this decadal rate from 1998 to 2015 and then continued until 2041, approximately 334,600 acres will have been harvested. In contrast, combining the actual acres harvested from 1998 to 2015 with the projected harvest of old-growth under each of the alternatives would produce a total of 54,400 to 81,600 acres of POG harvest through 2041. The acreage difference between these scenarios would result in between 253,000 and 280,200 fewer acres of harvested POG by 2041. Thus, matrix lands contain a substantially greater amount of POG than was assumed in the 1997 Forest Plan revision and many OGRs and non-Development LUDs are surrounded by additional unharvested areas.

Road construction on the Tongass has occurred primarily to access timber resources and future new road construction is anticipated to be similarly motivated. Future road construction will vary among alternatives by the amount of old-growth harvest. The cumulative extent of roads after implementation of any of the action alternatives, however, will be lower than anticipated under the 1997 Forest Plan. The additional old-growth harvest that would have occurred under full implementation of the 1997 Forest Plan was 474,000 acres of old-growth forest after 100 years. This harvest would have resulted in the need to construct nearly 4,000 miles of new road. As a result, NFS lands on the Tongass would have about 8,500 miles of road. This level of new road construction would create greater human access, increase

[1] Productive forest is capable of producing at least 20 cubic feet of wood fiber per acre per year, or having greater than 8,000 board feet per acre.

road densities, and result in additional habitat fragmentation compared with the present and future under the current alternatives. Instead, only about 440 miles of new road have been constructed during the past 20 years; about 1,800 miles of new road were expected to be constructed by the 1997 Forest Plan during the first two decades at full implementation. Further, the total road mileage on NFS lands under the current alternatives would be a maximum of 6,148 after 100 years from the present. This is 2,000 miles less than predicted by the 1997 Forest Plan, used in the evaluation of the conservation strategy. In other words, the miles of new road constructed under the current alternatives after 100 years, would be less than half the additional new miles expected to be constructed by the 1997 Forest Plan.

Overall, the conservation strategy protects slightly more than 90 percent of all existing POG forests on the Tongass National Forest. This percentage assumes that old-growth forest is harvested at the maximum allowable rate in each future decade before sufficient young-growth forest has reached harvestable size and can replace old-growth in the harvest. If this maximum rate does not occur, then the percentage of POG retained will be higher.

Ongoing GIS Mapping Updates

GIS mapping updates have resulted in substantial changes in estimated extent of the Tongass land base and vegetation mapping categories since 2008. The Tongass land base acreage changed as a result of two factors. First, updates were made to improve the accuracy of shoreline mapping and to reflect the land adjustments that occurred since 2008, in particular the land adjustments in the National Defense Authorization Act for Fiscal Year 2015 discussed below. These land base changes have directly affected the acreages in each vegetation category. Second, vegetation mapping is continually being updated; these updates have occurred both opportunistically in association with individual projects and forest-wide. A January 2015, forest-wide update corrected the mapping of a large number of polygons that were incorrectly mapped as size class 3 (young-growth sawtimber, less than 150 years old). As these polygons were older than 150 years old, they were corrected to size class 4, which converted them to productive old growth.

Modifications to the Conservation Strategy Since 2008

Modifications to the strategy from 1997 to 2007 were incorporated into the 2008 Forest Plan Amendment. Since 2008, one project has included modifications to the system of old-growth reserves. The Big Thorne Timber Sale project, located in north central Prince of Wales Island within the Thorne Bay Ranger District included small old-growth reserve boundary modifications intended to trade areas of inventoried roadless area (which would become Old-growth Habitat LUD) for roaded portions of old-growth reserves (which would become a development LUD and available for timber harvest). Small OGRs were modified in Value Comparison Units (VCU) 5790, 5800, 5810, 5820, 5830, 5850, and 5950, resulting in a net increase of 645 acres of Old-growth Habitat LUD. The Big Thorne FEIS analysis concluded that the old-growth reserve modifications would provide comparable achievement of Old-growth Habitat LUD goals and objectives, and therefore assumed that the functioning of the conservation strategy (USDA Forest Service 2013) would be maintained. These modifications amended the 2008 Forest Plan

A correction to the 2008 Forest Plan was made in 2012 (Forest Plan Errata, February 6, 2012), to correct a mapping error for a small OGR in VCU 7470 on the Ketchikan-Misty Fiords Ranger District. As a result of the correction, the size of the small OGR, as well as the acres of POG contained within, increased. No other changes to the spatial distribution, size, and composition of the Old-growth Habitat LUD or other non-development LUDs have occurred since approval of the 2008 Forest Plan Amendment.

External Factors that Have Affected the Conservation Strategy Since 2008

The National Defense Authorization Act for Fiscal Year 2015 conveyed 69,585 acres of NSF forest lands to the Sealaska Native Corporation to fulfil the commitment in the Alaska Native Claims Settlement Act (Public Law 113-2910). The conveyance affected old-growth reserves on Prince of Wales Island and in VCUs 5900, 5940, 6160, 6170, 6180, 6190, 6200, 6750, 6760 and 6850, and two smaller islands to the west (Kosciusko Island [VCUs 5450 and 5460] and Tuxekan Island [VCUs 5560, 5570, 5600 and 5872]). These areas are now non-NFS lands which are managed for timber production. In an effort to address

these effects under the proposed Forest Plan amendment, the Forest Service elected to propose boundary modifications to compensate for the loss of OGR acres. An Interagency Old-growth Reserve Review report is included in Appendix E of this EIS which outlines the proposed OGR modifications and rationale. Collectively the boundary modifications result in a net increase in 6,171 acres of OGR and 7,148 acres of POG forest included in the reserve system from existing (post-conveyance) levels. These modifications are part of Alternatives 2, 3, 4, and 5.

Another factor affecting the conservation strategy is the 2001 Roadless Area Conservation Rule (Roadless Rule). Inventoried roadless areas provide large, relatively undisturbed blocks of important habitat for a variety of terrestrial and aquatic wildlife and plants. Since its adoption in 2001, the Roadless Rule has been the subject of litigation concerning how it is to be applied to the Tongass. The suitable land base where timber harvest can occur has continually decreased over the years on the Tongass. One reason for the decrease is the withdrawal of inventoried roadless areas from lands suitable for timber production (see Forest Plan Appendix A).

When the 2008 Forest Plan was approved, the Tongass National Forest was temporarily exempted from the Roadless Rule per the 2003 Tongass Exemption (68 FR 75136). Exempting the Tongass from the application of the roadless rule left intact all old-growth reserves, riparian buffers, beach fringe buffers, and other protections contained in the 1997 Forest Plan, but made approximately 300,000 roadless acres available for forest management, including lands in development LUDs.

In 2011, the United States District Court, District of Alaska set aside the 2003 Tongass Exemption and reinstated the Roadless Rule with respect to the Tongass. A March 2014 ruling by the Ninth Circuit Court of Appeals reversed that decision. The Ninth Circuit Court of Appeals subsequently granted a petition for rehearing en banc, held in December 2014 before an eleven judge panel. On July 29, 2015, a six judge majority of the en banc panel held that USDA's justification for the Tongass Exemption was inadequate under the Administrative Procedure Act, holding it did not provide a reasoned explanation for contradicting the findings in the 2001 Record of Decision for the Roadless Rule. The majority upheld the District Court's reinstatement of the Roadless Rule. Consequently, the Roadless Rule remains in effect in Alaska and the Forest Service continues to apply the Rule to the Tongass National Forest. Therefore, inventoried roadless areas maintain additional old-growth forest that augment the amount maintained by the contributing elements of the conservation strategy (USDA Forest Service 2008c, page 21).

Proposed Modifications to Contributing Elements of the Conservation Strategy

This section describes the proposed modifications to the contributing elements of the conservation strategy. The Tongass National Forest timber program has historically focused on economical harvest of old-growth to "seek to meet" demands as directed by TTRA and to provide jobs to local communities in Southeast Alaska. The 2008 Forest Plan (Alternative 1) would transition to young-growth timber program in about 32 years, which reflects when the oldest young-growth stand within the development LUDs reach Culmination Mean Annual Increment (CMAI). On the Tongass National Forest, the CMAI occurs in stands at approximately 80 to 100 years. Therefore, to speed the transition to young-growth management over the next 10 to 15 years, the action alternatives propose young-growth harvest within non-development LUDs, the beach and estuary fringe, RMAs, and other areas within the matrix where suitable young-growth is available in order to get the necessary timber volume to meet these demands, such that at the end of this period the vast majority of timber sold by the Tongass National Forest will be young-growth. Anticipated transition times range from 12 years under Alternative 2 to 16 years under Alternatives 4 and 5.

Overall Approach to Young-growth Management

The general approach to young-growth management proposed under the alternatives is to speed the transition to a young-growth timber program. Young-growth harvest activities would occur within a previously disturbed footprint in areas of past timber harvest, and would maximize the use of existing or decommissioned roads to access harvest units where possible. The associated shift away from POG forest harvest would reduce the amount of future timber harvest and associated activities within intact and/or

unroaded areas. The alternatives that propose the fastest transition through more aggressive harvest strategies would result in less new road construction and less timber harvest in untouched areas; that is more timber harvest/road building would occur within previously disturbed areas, than alternatives with longer transition times. This tradeoff is the paramount difference among the alternatives.

Over half of the past timber harvest on the Tongass National Forest occurred when relatively few restrictions were in place in the 1960s and 1970s during the initial period of commercial-scale timber harvest and prior to the adoption of the first Forest Plan in 1979. Little protection was afforded to features such as the beach and estuary fringe, RMAs, and other sensitive areas identified now at the project level, such as karst and steep slopes, during this time. Future young-growth management activities would be required to comply with requirements for maintaining landscape connectivity, scenery, protecting steep slopes, high vulnerability soils, karst, and TTRA buffers under the proposed Forest Plan. Thus, young-growth harvest unit size in most cases would be smaller than the original units. Created openings within the beach and estuary fringe, RMAs, and OGRs proposed under the alternatives have the potential to reduce the functioning of these areas (discussed in detail below); however commercial thinning would enhance the habitat value of these areas by promoting the development of fewer, larger trees.

Old-growth Habitat LUD and Other Non-Development LUDs

The system of old-growth reserves (Old-growth Habitat LUD) and other non-development LUDs was established for the purpose of maintaining a functional and interconnected old-growth ecosystem (p. 3-11, USDA Forest Service 1997c). Of the 5.4 million acres of original (1954) POG that occurred on NFS lands on the Tongass National Forest about 92 percent remains in 2015. About 67 percent of the original acreage is protected within the reserve system. No changes are proposed to the size or spacing of the reserve system or the productive old-growth forest within these areas under the proposed Forest Plan amendment. Moreover, under all of the action alternatives the transition to young-growth management would substantially reduce the long-term POG forest harvest levels, with all of the alternatives retaining approximately 91 percent of the original POG after 100 years of plan implementation.

Currently, limited management of young-growth stands within the Old-growth Habitat LUD and some other non-development LUDs is allowed under the Forest Plan (Alternative 1) when conducted for the purpose of habitat enhancement (e.g., pre-commercial thinning to accelerate stand development toward old-growth conditions and other young-growth treatments to increase connectivity for wildlife). Under Alternatives 1 and 4, forest land in the non-development LUDs is identified as not suited for timber production. Under Alternatives 2, 3, and 5 (Old-growth Habitat LUD only), forest land in non-development LUDs is identified as suited for young-growth timber production. Even-aged commercial young-growth harvest in these LUDs could increase habitat fragmentation or perforation and reduce the ecological contribution of young-growth stands to the reserve system by setting back the trajectory toward late seral forest condition by delaying the development of old-growth stand characteristics such as snags, downed logs, and diverse tree canopy layers required by some POG-associated species (e.g., marten, goshawks, flying squirrels). Effects would be greatest under Alternatives 2 and 3 which allow multiple entries into harvested stands which would intensify and prolong the effects; the size of created openings are limited by only by scenery issues, similar to the current Forest Plan . Effects would be less under Alternative 5 which includes a one-time entry constraint and limits the size of created openings to less than 10 acres with maximum removal of up to 35 percent of the area of the original harvested stand, allowing the majority of each stand to mature to old-growth conditions after harvest (Tables 1 and 2). Thinning the entire stand could also be used to accelerate old-growth characteristics. Under Alternatives 2, 3, and 5, individual small OGRs could be modified to compensate for young-growth harvest. No harvest, except personal use and potentially salvage, would occur in OGRs or other non-development LUDs under Alternatives 1 and 4.

Young-growth forest comprises a relatively small proportion of the total area of these LUDs. The majority of the young-growth acres in the Old-growth Habitat LUD are concentrated in the North Central Prince of Wales and East Chichagof Island biogeographic provinces. The majority of the suitable young-growth acres in other non-development LUDs concentrated in the North Central Prince of Wales, West Baranof Island, and Kuiu Island biogeographic provinces (Table 3). These biogeographic provinces are therefore also where past timber harvest was concentrated.

Under Alternatives 2, 3, and 5 the maximum amount of young-growth harvest in the Old-growth Habitat LUD would comprise approximately 3.3 percent, 2.8 percent, and 0.2 percent of the forest land (young-growth, POG, and unproductive forest) within the Old-growth Habitat LUD Forest-wide, respectively (Table 3). By biogeographic province, maximum young-growth harvest would comprise 0 to 13.5 percent of forest land within the Old-growth Habitat LUD under Alternative 2, 0 to 7.8 percent under Alternative 3, and 0 to 0.8 percent under Alternative 5 (Table 3). Under Alternatives 2 and 3, the maximum amount of young-growth harvest in other non-development LUDs would comprise less than 1 percent of the forest land within these LUDs (Table 4). By biogeographic province, maximum young-growth harvest would comprise 0 to 9.7 percent of forest land within these LUDs under Alternative 2 and 0 to 8.8 percent under Alternative 3 (Table 4).

Suitable young-growth stands within OGRs and other non-development LUDS are typically located along the shoreline or adjacent to existing road systems. These easily accessible stands, particularly when located near other suitable young-growth stands in development LUDs, may be selected to avoid indirect effects to intact, relatively undisturbed POG forest within OGRs and other non-development LUDs.

Table 1
Proposed Young-growth Harvest after 100 Years in the Old-growth Habitat LUD and Other Non-Development LUDs by Alternative

	Proposed Young-growth Management in Non-development LUDs				
Alternative	**Non-Development LUDs where Young-growth Harvest Allowed**	**Number of Entries**	**Harvest Opening Limits**	**Stand Retention Limits**	**Total Projected Young-growth Harvest (Acres)**
Alternative 1	NA	NA	NA	NA	0
Alternative 2	Non-development LUDs[1]	Multiple	Limited by Scenery only	None	44,507
Alternative 3	Non-development LUDs[1]	Multiple	Limited by Scenery only	None	39,043
Alternative 4	NA	NA	NA	NA	0
Alternative 5	Old-growth Habitat LUD	One-time	10 acres or less	Maximum removal of 35 percent of original harvested stand acres	1,811

Note: NA = not applicable
[1] Does not include Experimental Forest, LUD II, Municipal Watershed, National Monument, Research Natural Area, Wilderness Monument, Wild River, and Wilderness

Young-growth forest stands have ecological values which contribute to the functioning of the reserve system. However, at the time of its development in 1997 it was assumed that the conservation strategy would maintain a functional and interconnected old-growth forest ecosystem without the additional contribution of previously harvested areas, either as young-growth or over time as these stands matured to old-growth condition. For this reason, and due to the spatial distribution and quantity of suitable young-growth, harvest in the Old-growth Habitat LUD and other non-development LUDs proposed under Alternatives 2, 3, and 5 would be expected to have a zero risk for Alternatives 1 and 4, a very low risk for Alternatives 2 and 3, and an almost zero risk for Alternative 5 of reducing the ability of the reserve system to maintain a functional and interconnected old-growth ecosystem, Therefore, all of the alternatives would maintain the integrity of the conservation strategy by maintaining the functioning of the reserve system.

Table 2
Proposed Young-growth Harvest by Treatment by Alternative

Category	Period	Acres by Treatment				
		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Old-growth Habitat LUD	1st 15 years	0 ac	2,477 CC ac	2,181 CC ac	0 ac	1,811 PC ac
	Last 85 years	0 ac	29,163 CC ac	24,005 CC ac	0 ac	0 ac
Other Non-Dev. LUDs	1st 15 years	0 ac	810 CC ac	726 CT ac	0 ac	0 ac
	Last 85 years	0 ac	12,058 CT ac	12,131 CT ac	0 ac	0 ac
Beach and Estuary Fringe	1st 15 years	0 ac	8,791 CC ac	7,819 CT ac	4,436 CT ac	3,903 PC ac
	Last 85 years	0 ac	13,079 CT ac	22,950 CT ac	6,678 CT ac	0 ac
RMA	1st 15 years	0 ac	2,327 CT ac	0 ac	0 ac	1,089 PC ac
	Last 85 years	0 ac	23,703 CT ac	0 ac	0 ac	0 ac

[1] CC = Clearcut;; CT = Commercial Thin
Note:
For CT, only 33% of the stand is removed; therefore, 1,000 ac of CT is roughly equivalent to removing 333 ac of trees spread over 1,000 ac
For PC under Alternative 5, only 35% of the stand is removed in patches no larger than 10 ac; so 1,000 ac of these created openings is roughly equivalent to removing 350 acres of trees in patches spread over 1,000 ac

Table 3
Distribution of Young-growth Harvest Acres (over 100 years) within the Old-growth Habitat LUD by Biogeographic Province and Alternative

	Biogeographic Province	Forest Land Acres[2]	Estimated Maximum Young-growth[1] Harvest in the Old-growth Habitat LUD (Young-growth Harvest Acres / % of Forest Land Acres in LUD)							
			Alts 1 and 4		Alt 2		Alt 3		Alt 5	
1	Yakutat Forelands	8,386	0	0%	8	0.1%	7	0.1%	0	0.0%
2	Yakutat Uplands	2,336	0	0%	0	0.0%	0	0.0%	0	0.0%
3	East Chichagof Island	150,445	0	0%	6,121	4.1%	5,045	3.4%	360	0.2%
4	West Chichagof Island	21	0	0%	0	0.0%	0	0.0%	0	0.0%
5	East Baranof Island	35,255	0	0%	1,198	3.4%	978	2.8%	66	0.2%
6	West Baranof Island	65,340	0	0%	2,038	3.1%	1,309	2.0%	124	0.2%
7	Admiralty Island	0	0	0%	0	0.0%	0	0.0%	0	0.0%
8	Lynn Canal	19,541	0	0%	855	4.4%	549	2.8%	51	0.3%
9	North Coast Range	58,511	0	0%	0	0.0%	0	0.0%	0	0.0%
10	Kupreanof/Mitkof Island	85,029	0	0%	2,470	2.9%	2,145	2.5%	129	0.2%
11	Kuiu Island	24,071	0	0%	938	3.9%	818	3.4%	55	0.2%
12	Central Coast Range	30,526	0	0%	48	0.2%	43	0.1%	3	0.0%
13	Etolin Island & Vicinity	95,865	0	0%	2,406	2.5%	2,133	2.2%	132	0.1%
14	North Central Prince of Wales	203,406	0	0%	10,844	5.3%	9,312	4.6%	622	0.3%
15	Revilla Island/ Cleveland Pen.	103,574	0	0%	2,445	2.4%	2,265	2.2%	131	0.1%
16	Southern Outer Islands	13,263	0	0%	573	4.3%	508	3.8%	34	0.3%
17	Dall Island and Vicinity	2,776	0	0%	0	0.0%	0	0.0%	0	0.0%
18	South Prince of Wales	35,627	0	0%	290	0.8%	313	0.9%	15	0.0%
19	North Misty Fiords	5,072	0	0%	227	4.5%	83	1.6%	14	0.3%
20	South Misty Fiords	0	0	0%	0	0.0%	0	0.0%	0	0.0%
21	Ice Fields	8,702	0	0%	1,177	13.5%	679	7.8%	74	0.8%
	Forest-wide	**947,746**	**0**	**0%**	**31,640**	**3.3%**	**26,186**	**2.8%**	**1,811**	**0.2%**

[1] For modeling purposes, it was assumed, based on an evaluation of economics, that the minimum harvestable age for young growth is 65 to 75 years old, depending on site index.
[2] Includes young-growth, productive old-growth, and unproductive forest; note that existing acreage does not include minor changes in the North Central Prince of Wales biogeographic province resulting from the proposed OGR modifications (Appendix E).

Table 4
Distribution of Young-growth Harvest Acres (over 100 years) within Other Non-Development LUDs Allowing Harvest[1] by Biogeographic Province and Alternative

			Estimated Maximum Young-growth[2] Harvest in Other Non-Development LUDs (Young-growth Harvest Acres / % of Forest Land Acres)					
	Biogeographic Province	Forest Land Acres[3]	Alts 1, 4, and 5		Alt 2		Alt 3	
1	Yakutat Forelands	34,086	0	0%	13	<0.1%	13	<0.1%
2	Yakutat Uplands	5,763	0	0%	218	3.8%	216	3.8%
3	East Chichagof Island	22,368	0	0%	186	0.8%	159	0.7%
4	West Chichagof Island	20,992	0	0%	0	0%	0	0%
5	East Baranof Island	51,589	0	0%	90	0.2%	90	0.2%
6	West Baranof Island	164,412	0	0%	2,508	1.5%	2,302	1.4%
7	Admiralty Island	55,246	0	0%	19	<0.1%	64	0.1%
8	Lynn Canal	112,641	0	0%	27	<0.1%	27	<0.1%
9	North Coast Range	173,152	0	0%	0	0%	252	0.1%
10	Kupreanof/Mitkof Island	68,844	0	0%	516	0.8%	498	0.7%
11	Kuiu Island	114,990	0	0%	618	0.5%	602	0.5%
12	Central Coast Range	141,205	0	0%	477	0.3%	415	0.3%
13	Etolin Island & Vicinity	7,722	0	0%	0	0%	0	0%
14	North Central Prince of Wales	60,718	0	0%	5,890	9.7%	5,326	8.8%
15	Revilla Island/ Cleveland Pen.	240,157	0	0%	983	0.4%	1,670	0.7%
16	Southern Outer Islands	24,468	0	0%	810	3.3%	764	3.1%
17	Dall Island and Vicinity	76,236	0	0%	242	0.3%	240	0.3%
18	South Prince of Wales	62,168	0	0%	128	0.2%	127	0.2%
19	North Misty Fiords	58,540	0	0%	49	0.1%	49	0.1%
20	South Misty Fiords	0	0	0%	0	0%	0	0%
21	Ice Fields	122,223	0	0%	92	0.1%	43	<0.1%
	Forest-wide	**1,617,519**	**0**	**0%**	**12,868**	**0.8%**	**12,857**	**0.8%**

[1] Includes Semi-Remote Recreation, Remote Recreation, Special Interest Area, Recreational River, and Scenic River.
[2] For modeling purposes, it was assumed, based on an evaluation of economics, that the minimum harvestable age for young growth is 65 to 75 years old, depending on site index.
[3] Includes young-growth, productive old-growth, and unproductive forest.

Proposed Modifications to Forest Plan Standards and Guidelines

This section describes the proposed modifications to contributing elements of the conservation strategy that are specifically addressed through Forest Plan standards and guidelines.

Beach and Estuary Fringe

The beach and estuary fringe is a 1,000-ft wide corridor adjacent to saltwater shorelines; it is consists of POG, but is also comprised of unproductive forest, previously harvested forest, and non-forest types. It serves as a transition zone between upland forest and saltwater influences, and as such is distinguished as a separate ecosystem (microclimate) within the larger old-growth forest ecosystem. The beach and estuary fringe is considered a high value habitat for many species including brown bears, black bears, bald eagles, goshawks, deer, marten, and others (Appendix D, USDA Forest Service 2008b). The beach and estuary fringe also provides horizontal or low-elevation connectivity between watersheds, many of which otherwise have very steep slopes and/or non-forested ridge tops, offering important travel corridors for wildlife. Although not explicitly discussed in the conservation strategy, the beach and estuary fringe also provides an important function to the marine and estuarine environment by reducing downslope effects to marine waters (e.g., sediment runoff), shading shoreline beach areas, providing large-woody debris and other organic inputs to the marine and estuarine systems, and providing bank stability (root system of large trees). The beach and estuary fringe is particularly critical on the Tongass National Forest given the extensive amount of shoreline (more than 17,000 miles) that exists on more than 22,000 islands.

Young-growth stands within the beach and estuary fringe are lower value habitat for old-growth associated wildlife species because they do not possess the stand characteristics required by some species (snags, downed logs, large trees). However, they contribute to functional connectivity for the movement and dispersal of wildlife and serve as buffers between areas of suitable habitat and human activity. It can be assumed that the integrity of the conservation strategy is maintained when the beach and estuary fringe continues to provide the functions of a transition zone between interior forest and saltwater influences, landscape connectivity, and water quality and habitat benefits to the marine environment.

The 2008 Forest Plan, Alternative 1, includes forest-wide Beach and Estuary Fringe standards and guidelines that prohibit timber harvest within 1,000 feet inland from mean high tide. This buffer was intended to provide effective landscape linkages to enhance the reserve system, protect bald-eagle habitat, buffer the primary beach fringe zone (0 to 500 feet of the shoreline) from wind throw, maintain a functional interior forest zone within the beach fringe, and sustain habitats for goshawks (Appendix D, USDA Forest Service 2008b). Currently, limited management of young-growth stands within the beach and estuary fringe is allowed under the Forest Plan for the purpose of habitat enhancement (e.g., pre-commercial thinning to accelerate stand development toward old-growth conditions).

Under Alternatives 2, 3, 4, and 5 forest land in the beach and estuary fringe is identified as suitable for young-growth timber production, and commercial young-growth harvest and road construction/reconstruction in the beach and estuary fringe is allowed under these alternatives (Table 5). Young-growth harvest in the beach and estuary fringe has the potential to locally decrease buffer width and reduce its effectiveness in facilitating the movement of organisms across the landscape and providing habitat for wildlife species that are negatively affected by edge. Alternatives that allow clearcutting (Alternatives 2 and 5), or the greatest amounts of road construction/reconstruction (Alternatives 2 and 3) are most likely to increase habitat fragmentation if openings are too large to be crossed by species with limited dispersal capabilities. Young-growth harvest may also delay the development of old-growth stand characteristics in the beach and estuary fringe or may enhance the growth of the remaining trees through thinning.

Table 5
Proposed Young-growth Harvest after 100 Years in the Beach and Estuary Fringe by Alternative

	Beach and Estuary Fringe Management Approach					
Alternative	Number of Entries	Harvest Opening Limits	Stand Treatments and Timing Restrictions[1]	Timber Removal Limits	Additional Measures	Projected Harvest over 100 yrs (Acres)
Alternative 1	NA	NA	NA	NA	NA	0
Alternative 2	Multiple	Limited by Scenery only	CC for first 15 years; CT thereafter	None	1,000-foot-wide corridor adjacent to even-aged harvest units	21,871
Alternative 3	Multiple	NA	CT only (no time limit)	Maximum removal of 33 percent basal area	None	30,769
Alternative 4	Multiple	NA	CT only (no time limit)	Maximum removal of 33 percent basal area	None	11,114
Alternative 5	One-time	10 acres or less	PC or CT for first 15 years	Maximum removal of up to 35 percent of original stand acres	200-ft buffer adjacent to shoreline	3,903

Note: NA = not applicable
[1] CC = Clearcut; PC = Patch Cut; CT = Commercial Thin

The most intensive young-growth harvest in the beach and estuary fringe would occur under Alternative 2 which proposes the greatest amount of harvest and would allow clearcutting to the shoreline during the first 15 years after plan approval and commercial thinning thereafter (Table 2). Alternative 2 includes the following management approach: When even-aged management of young growth occurs in the beach and estuary fringe, the intent is to maintain an approximate 1,000-foot wide protected corridor adjacent inland of the harvest unit to function as alternate, low elevation, forested habitat and corridor. This corridor should be in POG or young-growth, where present, that meets the objectives of the beach fringe, and should be located less than 800 feet in elevation. Beach and estuary standards and guidelines would apply as if this were the original beach buffer. Effects under this alternative would be long-term as multiple entries into stands, or reharvesting the same stand, would be allowed over the planning horizon. Under Alternative 2, shifting the beach and estuary fringe inland would maintain some level of connectivity between watersheds but would locally reduce the ability of the buffer to serve as a transitional zone between interior forest and marine influence.

Less intensive effects to the beach and estuary fringe would occur under Alternatives 3 and 4 (second and third most young-growth acres proposed for harvest, respectively) which would allow commercial thinning (multiple entries) throughout Forest Plan implementation (Tables 2 and 5). Commercial thinning would maintain more of the functions of the beach and estuary fringe than clearcutting or group selection; however, some harvested stands would be managed (i.e., could have more than one entry) over the long-term (i.e., 60 or more years after initial entry).

The effects would be even lower to the beach and estuary fringe under Alternative 5 which proposes the least amount of harvest. Although Alternative 5 would allow created openings of up to 10-acre or commercial thinning, harvest would be limited to the first 15 years after Forest Plan approval (Tables 2 and 5) and only 3,550 acres of young-growth are projected to be managed with no more than 35 percent of each stand harvested). Alternative 5 also includes a 200-foot-wide forested buffer along the shoreline adjacent to harvest units which would continue to protect forest in the beach and estuary fringe for connectivity and habitat while the harvested stand matures. Thus, the functioning of the beach and estuary fringe may be reduced in places due to the reduced buffer, but effects would be long-term and more localized.

Overall, suitable young-growth comprises a small portion of the total amount of beach and estuary fringe within each biogeographic province, most of which occurs in the Etolin Island and Vicinity, North Central Prince of Wales, and Revilla Island/Cleveland Peninsula biogeographic provinces (Table 6). Forest-wide maximum young-growth harvest would affect approximately 2.4 percent, 3.3 percent, 1.2 percent, and 0.4 of the forest land within the beach and estuary fringe (all acres included) under Alternatives 2, 3, 4, and 5, respectively (Table 6). By biogeographic province, maximum young-growth harvest would affect 0 to 5.6 percent of forest land within the beach and estuary fringe under Alternative 2, 0 to 8.1 percent under Alternative 3, 0 to 3.5 percent under Alternative 4, and 0 to 1.1 percent under Alternative 5. Due to the localized nature of anticipated effects, under all of the alternatives the beach and estuary fringe would continue to act as a transition zone between interior forest and saltwater influences, maintain landscape connectivity, and provide benefits to the marine environment across the planning area. Therefore, it would be expected that there may be localized reductions in the ability of the beach and estuary fringe to function as intended under the conservation strategy under each of the alternatives but Forest-wide effects would not measurably reduce the functioning of this contributing element of the conservation strategy.

Table 6
Distribution of Young-growth Harvest Acres (over 100 years) within the Beach and Estuary Fringe by Biogeographic Province and Alternative

	Biogeographic Province	Forest Land Acres in Beach & Estuary Fringe[2]	Estimated Maximum Young-growth Harvest[1] in the Beach Fringe (Young-growth Harvest Acres / % of Forest Land Acres))									
			Alt 1		Alt 2		Alt 3		Alt 4		Alt 5	
1	Yakutat Forelands	6,467	0	0%	7	0.1%	11	0.2%	3	<0.1%	2	<0.1%
2	Yakutat Uplands	8,397	0	0%	0	0%	0	0%	0	0%	0	0%
3	East Chichagof Island	63,036	0	0%	2,087	3.3%	2,470	3.9%	741	1.2%	420	0.7%
4	West Chichagof Island	37,246	0	0%	0	0%	0	0%	0	0%	0	0%
5	East Baranof Island	30,341	0	0%	1,513	5.0%	2,103	6.9%	992	3.3%	314	1.0%
6	West Baranof Island	79,821	0	0%	1,168	1.5%	1,525	1.9%	177	0.2%	80	0.1%
7	Admiralty Island	79,128	0	0%	12	<0.1%	54	0.1%	0	0%	0	0%
8	Lynn Canal	17,923	0	0%	261	1.5%	231	1.3%	13	0.1%	58	0.32%
9	North Coast Range	46,054	0	0%	44	0.1%	227	0.5%	0	0%	8	0.0%
10	Kupreanof/Mitkof Island	38,537	0	0%	2,165	5.6%	3,135	8.1%	450	1.2%	398	1.0%
11	Kuiu Island	70,721	0	0%	944	1.3%	1,351	1.9%	266	0.4%	175	0.2%
12	Central Coast Range	23,755	0	0%	584	2.5%	788	3.3%	211	0.9%	74	0.3%
13	Etolin Island & Vicinity	54,051	0	0%	2,922	5.4%	4,247	7.9%	1,874	3.5%	594	1.1%
14	North Central Prince of Wales	88,369	0	0%	4,856	5.5%	6,872	7.8%	2,946	3.3%	815	0.9%
15	Revilla Island/ Cleveland Pen.	84,629	0	0%	3,957	4.7%	5,892	7.0%	2,588	3.1%	728	0.9%
16	Southern Outer Islands	44,539	0	0%	779	1.7%	1,062	2.4%	683	1.5%	164	0.4%
17	Dall Island and Vicinity	22,452	0	0%	89	0.4%	132	0.6%	0	0%		0.0%
18	South Prince of Wales	48,991	0	0%	438	0.9%	605	1.2%	169	0.3%	68	0.1%
19	North Misty Fiords	26,483	0	0%	44	0.2%	64	0.2%	0	0%	4	0.0%
20	South Misty Fiords	53,091	0	0%	0	0%	0	0%	0	0%	0	0.0%
21	Ice Fields	0	0	0%	0	0%	0	0%	0	0%	0	0%
	Forest-wide	**924,030**	**0**	**0%**	**21,871**	**2.4%**	**30,769**	**3.3%**	**11,114**	**1.2%**	**3,903**	**0.4%**

[1] For modeling purposes, it was assumed, based on an evaluation of economics, that the minimum harvestable age for young growth is 65 to 75 years old, depending on site index.
[2] Includes young-growth, POG, and unproductive forest.

Riparian Management Areas

Riparian areas are the corridors along streams and rivers which provide an interface between upland forests and riverine influences, distinguishing them as a unique ecosystem within the larger forest ecosystem. Riparian areas support some of the most productive stands of old-growth on the Tongass National Forest, and provide habitat for species associated with aquatic environments (e.g., amphibians and furbearers such as river otters) and terrestrial species for which fish are an important food sources (e.g., brown bears and black bears). Riparian areas follow the dendritic nature of river systems and provide forested corridors connecting higher elevation regions in upper watersheds with lower elevation forests in the valley bottoms, providing connectivity within watersheds. Young-growth stands within the riparian areas comprise lower value habitat for old-growth associated wildlife species; however, they maintain functional connectivity for the movement and dispersal of wildlife and serve as buffers between areas of suitable habitat and human activity.

Riparian areas are protected through use of the Fish and Riparian Standards and Guidelines that prohibit timber harvest within a certain distance of streams (depending on stream type or process group). These areas include the 1990 TTRA 100-foot-wide buffers and additional distances intended to preserve the functions of the riparian areas with the sum of both designated as RMA (Section 102 of TTRA). They are intended to maintain anadromous fish habitat (e.g., supplying large-woody debris), maintain water quality (shading, reducing sediment runoff), and provide elevational connectivity within watersheds (Appendix D, USDA Forest Service 2008b). It can be assumed that the integrity of the conservation strategy is maintained when riparian areas continue to support aquatic and terrestrial habitats, maintain water quality and provide landscape connectivity. Currently, limited management of young-growth stands within RMAs is allowed under the 2008 Forest Plan (Alternative 1) when conducted for the purpose of habitat enhancement (e.g., pre-commercial thinning to accelerate stand development toward old-growth conditions).

Commercial young-growth harvest and road construction/reconstruction in the RMA (outside of TTRA buffers), is proposed under Alternatives 2 and 5 within the development LUDs and those non-development LUDs discussed above; no young-growth harvest would occur in the RMA under Alternatives 1, 3, and 4 (Tables 2 and 7). Alternative 2 would allow commercial thinning throughout the life of the Forest Plan. Alternative 5 could be more intense in that it would allow clearings of up to 10 acres or commercial thinning within RMAs, but only during the first 15 years after Forest Plan approval. Young-growth harvest in the RMA has the potential to locally decrease buffer width and reduce its effectiveness in facilitating the movement of organisms across the landscape and reduce the function of riparian areas. Young-growth harvest may also delay the development of old-growth stand characteristics in RMAs. Effects to the conservation strategy would be least under Alternative 5 due to the one-time entry constraint and limited number of harvested acres (Table 7). Under both alternatives, TTRA buffers would continue to protect aquatic systems and maintain functions such as large-woody debris input, shading, and nutrient inputs to streams. Additionally TTRA buffers would maintain elevational connectivity, though potentially through narrower corridors where young-growth harvest units occur.

Overall, suitable young-growth comprises a small portion of the total amount of RMA (outside of TTRA buffers) within each biogeographic province (Table 8). Suitable young-growth in RMAs is spread throughout the forest, with larger concentrations occurring in the North Central Prince of Wales, West Baranof Island, and East Baranof Island biogeographic provinces (Table 8). Forest-wide maximum young-growth harvest would affect approximately 6.7 percent and less than 1 percent of the forest land within RMAs, outside of TTRA buffers under Alternatives 2 and 5, respectively (Table 8). By biogeographic province, maximum young-growth harvest would affect 0 to 17.2 percent of forest land within RMAs (outside of TTRA buffers) under Alternative 2 and 0 to 0.8 percent under Alternative 5 (Table 8). Due to the localized nature of anticipated effects, under all of the alternatives riparian areas would continue to maintain aquatic and terrestrial habitats, maintain water quality, and provide landscape connectivity across the planning area. Therefore, it would be expected that there may be localized reductions in the ability of the RMAs to function as intended under the conservation strategy under each of the alternatives but Forest-wide effects would not measurably reduce the functioning of this contributing element of the conservation strategy.

Table 7
Proposed Young-growth Harvest after 100 Years in Riparian Management Areas (Outside of TTRA buffers) by Alternative

Alternative	RMA Management Approach					Total Projected Harvest (Acres)
	Number of Entries	Harvest Opening Limits	Stand Treatments and Timing Restrictions[1]	Timber Removal Limits	Additional Measures	
Alternative 1	NA	NA	NA	None	NA	0
Alternative 2	Multiple	NA	CT only (no time limit)	None	NA	26,030
Alternative 3	NA	NA	NA	None	NA	0
Alternative 4	NA	NA	NA	None	NA	0
Alternative 5	One-time	< 10 acres	PC or CT for first 15 years	Maximum removal of up to 35 percent of original harvested stand acre	NA	1,089

Note: NA = not applicable
[1] CC = Clearcut; PC = Patch Cut; CT = Commercial Thin

Table 8
Distribution of Young-growth Harvest Acres (over 100 years) in Riparian Management Areas by Biogeographic Province and Alternative

	Biogeographic Province	Forest Land Acres in RMAs Outside of TTRA Buffers)[2]	Estimated Maximum Young-growth Harvest[1] in RMAs (Young-growth Harvest Acres / % of Forest Land Acres))					
			Alts 1, 3, and 4		Alt 2		Alt 5	
1	Yakutat Forelands	28,564	0	0%	36	0.1%	1	<0.1%
2	Yakutat Uplands	4,059	0	0%	28	0.7%	1	<0.1%
3	East Chichagof Island	41,682	0	0%	5,040	12.1%	222	0.5%
4	West Chichagof Island	4,388	0	0%	0	0.0%	0	0%
5	East Baranof Island	8,949	0	0%	1,540	17.2%	68	0.8%
6	West Baranof Island	17,541	0	0%	2,725	15.5%	113	0.6%
7	Admiralty Island	16,096	0	0%	0	0.0%	0	0%
8	Lynn Canal	16,156	0	0%	1,551	9.6%	70	0.4%
9	North Coast Range	22,508	0	0%	12	0.1%	0	0%
10	Kupreanof/Mitkof Island	18,557	0	0%	637	3.4%	25	0.1%
11	Kuiu Island	14,984	0	0%	867	5.8%	38	0.3%
12	Central Coast Range	27,947	0	0%	945	3.4%	38	0.1%
13	Etolin Island & Vicinity	11,947	0	0%	797	6.7%	33	0.3%

Table 8 (continued)
Distribution of Young-growth Harvest Acres (over 100 years) in Riparian Management Areas by Biogeographic Province and Alternative.

	Biogeographic Province	Forest Land Acres in RMAs Outside of TTRA Buffers)[2]	Estimated Maximum Young-growth Harvest[1] in RMAs (Young-growth Harvest Acres / % of Forest Land Acres))					
			Alts 1, 3, and 4		Alt 2		Alt 5	
14	North Central Prince of Wales	49,627	0	0%	7,842	15.8%	314	0.6%
15	Revilla Island/ Cleveland Pen.	36,834	0	0%	2,017	5.5%	82	0.2%
16	Southern Outer Islands	5,553	0	0%	431	7.8%	16	0.3%
17	Dall Island and Vicinity	2,830	0	0%	4	0.1%	0	0%
18	South Prince of Wales	10,457	0	0%	183	1.7%	7	0.1%
19	North Misty Fiords	16,858	0	0%	320	1.9%	15	0.1%
20	South Misty Fiords	17,462	0	0%	0	0.0%	0	0%
21	Ice Fields	17,489	0	0%	1,056	6.0%	46	0.3%
	Forest-wide	390,490	**0**	**0%**	26,030	6.7%	1,089	0.3%

[1] For modeling purposes, it was assumed, based on an evaluation of economics, that the minimum harvestable age for young growth is 65 to 75 years old, depending on site index.
[2] Includes young-growth, productive old-growth, and unproductive forest.

Legacy Forest Structure

The Legacy Forest Structure (Legacy) standard and guideline was added to the Forest Plan in 2008, and was intended as an ecological approach to Forest-wide retention of old-growth habitat characteristics (e.g., large trees, downed logs, and snags) in high risk biogeographic provinces. The Legacy standard and guideline evolved from considerations presented at the Interagency Conservation Strategy Review workshop (USDA Forest Service 2007) and replaced species-specific goshawk foraging and marten standards and guidelines. It applies to those VCUs that have had or are anticipated to have high levels of timber harvest (a list is provided in the Forest Plan; USDA Forest Service 2008a) for old-growth harvest openings greater than 20 acres in size.

Alternative 1 includes the current Legacy standard and guideline. Alternatives 2, 3, 4, and 5 include the current Legacy standard and guideline with a proposed clarification that the VCUs where the Legacy standards and guidelines apply should be verified during project-specific planning and analysis based on harvest standards listed in the Forest Plan. The Legacy Forest Structure standard and guideline would continue to maintain habitats used by old-growth associated species in the VCUs where it applies.

Wildlife

Alternatives 2, 3, 4, and 5 propose a revision to the Goshawk standards and guidelines which address nesting habitat. These standards and guidelines expand the requirement to maintain 100 acres of POG forest surrounding a nest tree or nest site to include the largest diameter young-growth forest if POG alone is not sufficient. The proposed modification would provide greater protection to goshawks and their habitat, and therefore would strengthen this standard and guideline because goshawks will nest in maturing young-growth forest with sufficient structure, if mature and old-growth forest is unavailable, and will also forage in these areas (Reynolds et al. 2006; Boyce et al. 2006). Therefore, the proposed

modification would provide enhanced protection to goshawk habitat in situations where there are less than 100 acres of POG surrounding a nest tree or nest site.

Other Non-wildlife Standards and Guidelines

The current Forest Plan includes a number of other standards and guidelines which preclude or significantly limit timber harvest to protect resources other than wildlife. They apply to areas of high hazard soils, steep slopes, karst terrain, scenic integrity objectives (SIOs) for visually sensitive travel routes and use areas, and timber stands that are technically not feasible to harvest. The retention of old-growth forest provided by these standards and guidelines enhances the conservation strategy, although they were designed with effects to visual resources in mind rather than their potential benefits to wildlife exclusively (Appendix D, USDA Forest Service 2008b).

Alternatives that modify the current standards and guidelines to make young-growth available for harvest would reduce the amount of "additional" retention of forest within the matrix; however, they would not result in additional POG harvest. Alternatives 2, 3, and 4 would allow commercial thinning of young-growth in high vulnerability karst areas. Alternatives 2, 3, and 5 would change the SIO to low SIO for young-growth harvest which allows for larger openings.

Integrity of the Conservation Strategy

Land management on the Tongass National Forest presents a careful balance between ecological, economic, and social (community) values. The conservation strategy is intended to maintain ecological values and certain economic and social values, while allowing other multiple uses (e.g., timber production, renewable energy/infrastructure development, recreation, tourism, mining, and subsistence) to occur on the Tongass National Forest. As such, the conservation strategy is not "risk free" but is intended to balance an acceptable level of risk in ensuring support of well-distributed, viable wildlife populations while meeting the requirements of the National Forest Management Act (PL 86-517; 16 USC §528) and Multiple Use Sustainable Yield Act (PL 94-588; 16 USC §1600).

Overall, the conservation strategy is functioning under conditions that represent stronger conservation practice than anticipated at the time of its development. Actual and projected old-growth harvest under the existing Forest Plan are far below levels predicted under the 1997 Forest Plan, which formed the context within which the conservation strategy was analyzed and intended to function. This has occurred because of economics and a significant decline in the timber industry due to various factors. But most importantly, with the 2001 Roadless Rule in effect, inventoried roadless areas (approximately 2,143,000 acres of development LUDs in roadless areas containing about 823,000 acres of POG) make a major contribution to the maintenance of ecological function on the Tongass National Forest but do so outside of the elements of the conservation strategy. Under the 1997 Forest Plan, it was projected that 84 percent of the original (1954) POG forest would remain in 100 years (Table 9). Under the preferred alternative (Alternative 5) and the other action alternatives, 91 percent of the original POG forest is anticipated to remain. This equates to approximately 400,000 acres of additional old-growth than were assumed during the development and evaluation of the conservation strategy. Likewise, under the 1997 Forest Plan approximately 8,500 miles of roads were anticipated to exist by 2095, whereas under the current Forest Plan Amendment alternatives less than 6,200 miles of roads are anticipated by 2095. This translates to substantially lower road densities under the current Forest Plan and the action alternatives, compared to the 1997 Plan (Table 9). The additional area of POG will function as additional reserves, enhancing the existing reserves, and increasing the effectiveness of the matrix when located around harvest units. As such, the substantially greater spatial extent of old-growth forest on the landscape and fewer roads across the planning area would outweigh the local, adverse effects of young-growth harvest proposed in the Old-growth Habitat LUD, the beach and estuary fringe, and RMAs that would result under the action alternatives as described below.

Proposed modifications to contributing elements of the conservation strategy (e.g., beach and estuary fringe, RMAs, and non-development LUDs) under Alternatives 2, 3, 4, and 5 have the potential to result in localized reductions in the functioning of these elements. That is, young-growth harvest will locally alter forest structure and may reduce connectivity, but the beach and estuary fringe and RMAs would continue to function as intended across the planning area by serving as ecological transition zones, maintaining freshwater and marine aquatic and terrestrial habitat, and providing landscape connectivity. Therefore,

none of the alternatives, when considered in whole, would reduce the ability of the conservation strategy to maintain a functional and interconnected old-growth ecosystem across the planning area and the overall functioning of the conservation strategy in terms of its ability to maintain viable, well-distributed populations of wildlife across the planning area would remain.

Under all of the alternatives the extent of localized effects to contributing elements of the conservation strategy would depend on project-level decisions and strategic implementation of standard and guidelines, such as the landscape connectivity standard and guideline, which are intended to provide important safeguards towards ensuring the sustainability of populations of old-growth associated species. The consideration of geographic scale is important on the Tongass National Forest because it is an island ecosystem, with individual islands at times functioning as metapopulations (many independent populations with limited interchange) for some species that do not frequently disperse between islands. The responsibility for ensuring the effectiveness of the conservation strategy at finer scales (i.e., biogeographic provinces or groups of island), falls on decisions made at the project scale taking into account the configuration of individual landscapes. All projects must demonstrate consistency with Forest Plan components, such as the Landscape Connectivity, Legacy, and species-specific standards and guidelines. This ensures that the Forest Plan is implemented effectively across the planning area, including portions, such as the North Central Prince of Wales biogeographic province which have experienced larger amounts of timber harvest and associated developments than other areas. Thus, the primary difference among alternatives is how the transition to young-growth management would be reached, including the timing, intensity, and extent of old-growth versus young-growth harvest; therefore, the alternatives vary in the approach employed to maintain the integrity of the conservation strategy. However, under all alternatives the integrity of the conservation strategy would be maintained.

The following paragraphs summarize characteristics of each alternative and review how each maintains the integrity of the conservation strategy, beginning with the current Forest Plan (Alternative 1). The action alternatives are then described in order of the level of risk they present to localized reductions in the functioning of contributing elements of the conservation strategy, from greatest to least risk.

Under Alternative 1, the current Forest Plan, the integrity of the conservation strategy would be maintained because no modifications to its contributing elements are proposed. The conservation strategy would continue to function as designed. As outlined above, the history of old-growth harvest since 1997 results in a stronger conservation environment than anticipated when the Forest Plan was developed and analyzed. Therefore, under Alternative 1 it is expected that viable, well-distributed wildlife populations would be maintained across the planning area (USDA Forest Service 2008b). The level of old-growth harvest would be much lower than allowed by the existing Forest Plan, in order to transition toward a greater level of young-growth harvest. However, Alternative 1 would not expedite the transition to young-growth management to the degree of the action alternatives, and therefore, would result in the greatest amount of old-growth timber harvest among the alternatives.

Alternative 2 would have the greatest risk of localized reductions in the functioning of contributing elements of the conservation strategy because it would result in the most young-growth harvest, would allow clearcutting young growth in non-Development LUDs, would allow clearcutting young growth in the beach and estuary fringe for the first 15 years after Forest Plan approval, and would allow commercial thinning of young growth in RMAs (Table 9). Alternative 2 would mitigate beach fringe harvest by shifting the beach and estuary fringe inland, maintaining elements of horizontal connectivity between watersheds but reducing effectiveness to serve as a transitional zone between interior forest and marine influence in those areas of harvest. Alternative 2 would result in the shortest transition time (about 12 years) and would therefore result in the lowest amount of old-growth harvest, minimizing the amount of new road construction and POG harvest in undeveloped/intact areas.

Alternative 3 would have the second greatest risk of localized reductions in the functioning of contributing elements of the conservation strategy. It would result in the second highest amount of young-growth harvest, but unlike Alternative 2 would not allow clearcutting in the beach and estuary fringe (commercial thinning only) or any harvest in RMAs. However, this alternative would involve the greatest amount of road construction/reconstruction some of which would occur within the beach and estuary fringe.

Alternative 3 would result in the second shortest transition time (about 13 years), and therefore would result in the second lowest amount of POG harvest (Table 9).

Alternative 5 would have the third greatest risk of localized reductions in the functioning of contributing elements of the conservation strategy. It would allow created openings of less than 10 acres or commercial thinning of young growth in the beach and estuary fringe and RMAs but only during the first 15 years after Forest Plan approval; effects to wildlife habitat and connectivity would be minimized by limiting the size of harvest openings, allowing removal of a maximum of 35 percent of a previously harvested stand, and implementing a one-time entry stipulation. Additionally, Alternative 5 would maintain a beach and estuary buffer, albeit at a reduced width (200-feetwide), adjacent to the shoreline, which would maintain some connectivity. Alternative 5 would allow young-growth harvest in the Old-growth Habitat LUD during the first 15 years after Forest Plan approval, but would not allow harvest in any other non-development LUD (Table 9). Alternative 5 would result in the third shortest transition time (about 16 years), and would result in the third lowest amount of POG harvest.

Alternative 4 would have the lowest risk of localized reductions in the functioning of contributing elements of the conservation strategy because no harvest would occur in any non-development LUD or within RMAs, and only commercial thinning of young growth would be allowed within the beach and estuary fringe. Alternative 4 would affect the smallest land base (Phase I lands only), and would result in the third shortest transition time (about 16 years; same as Alternative 5), but with the least amount of total harvest (Table 89).

One of the objectives of the Forest Plan was to “”[P]rovide sufficient habitat to preclude the need for listing of species under the Endangered Species Act, or from becoming listed as Sensitive due to National Forest habitat conditions” (USDA Forest Service 2008a p. 2-4). Although no terrestrial species in Southeast Alaska are listed under the ESA, petitions have been filed for the Alexander Archipelago wolf (2011), Queen Charlotte goshawk (1994), and Prince of Wales flying squirrel (2011). The conservation strategy was designed to conserve, and thereby avoid the need to list these and other old-growth associated species. All of the alternatives are expected to maintain a functional and interconnected old-growth ecosystem, capable of supporting well-distributed, viable wildlife populations of wildlife across the planning area; therefore none of them are expected to increase the likelihood of species listing under the ESA.

Monitoring, the systematic process of collecting information to evaluate effects of actions or changes in conditions or relationships (36 CFR 219.19), is a quality control process for implementation of the Tongass Forest Plan. It provides the public, the Forest Service, and other involved resource agencies with information on the progress and results of Forest Plan implementation. As such, monitoring, along with the evaluation of that monitoring, comprise an essential feedback mechanism within an adaptive management framework to keep the Forest Plan dynamic and responsive to changing conditions. The evaluation process also provides feedback that can trigger corrective action, adjustment of plans and budgets, or both, to facilitate feasible and meaningful action on the ground.

The Forest Plan monitoring program is an important mechanism for confirming that the transition to young-growth management is achieving the desired effects. It allows the Forest Service to respond to new information and/or changing conditions, thereby working to ensure that there are no unintended consequences of the transition to a young-growth based timber program. The monitoring program is being modified concurrently with the proposed Forest Plan amendment to meet the requirements of the 2012 Planning Rule (Forest Service Handbook 1909.12, chapter 30, section 32.3). The Forest Service is developing monitoring questions associated with biodiversity, wildlife, and streams and fish habitat (among other topics) which speak to the effects of young-growth management. Draft monitoring questions address the ability of young-growth harvest to improve habitat for wildlife and timber production, and the ability of riparian vegetation to support key riparian functions. Monitoring data will allow the Forest Service to evaluate and change silvicultural prescriptions and other practices as needed to ensure continued functioning of contributing elements of the conservation strategy across the planning area.

Table 9
Summary of Effects by Alternative and Comparison with 1997 Forest Plan

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Projected acres of POG harvested under 1997 Forest Plan through 2095	474,000	474,000	474,000	474,000	474,000
Actual acres of POG harvested since 1995 plus projected acres of harvest under 2016 Forest Plan through 2095	100,517	70,274	73,233	80,262	80,144
Projected Percent of POG remaining in 2095 under 1997 Forest Plan	84	84	84	84	84
Projected Percent of POG remaining in 2095 under 2016 Forest Plan	90	91	91	91	91
Projected Road Miles/Road Density (mi/sq mi) on NFS Lands under 1997 Forest Plan in 2095	8,500 mi 0.32 mi/mi^2	8,500 mi 0.32 mi/mi^2	8,500 mi 0.32 mi/mi^2	8,500 mi 0.32 mi/mi^2	8,500 mi 0.32 mi/mi^2
Projected Road Miles/Road Density (mi/sq mi) on NFS Lands under 2016 Forest Plan in 2095	6,036 mi 0.23 mi/mi^2	6,148 mi 0.23 mi/mi^2	6,113 mi 0.23 mi/mi^2	5,964 mi 0.23 mi/ mi^2	6,086 mi 0.23 mi/ mi^2
Estimated Years to Fully Transition to Young-growth Management	32 years	12 years	13 years	16 years	16 years
Projected Young-growth Harvest in Old-Growth Habitat LUD (acres)	0	31,640	26,186	0	1,811
Projected Young-growth Harvest in Old-growth Habitat LUD as a % of Forest Land Acres in Old-growth Habitat LUD	0%	3.3%	2.8%	0%	0.2%
Projected Young-growth Harvest in Other Non-Dev. LUDs (acres)	0	12,868	12,857	0	0
Projected Young-growth Harvest in Other Non-Dev. LUDs as a % of Forest Land Acres in Other Non-Dev. LUDs	0%	0.8%	0.8%	0%	0%
Projected Young-growth harvest in Beach and Estuary Fringe (ac)	0	21,871	30,769	11,114	3,903
Projected Young-growth Harvest in Beach/Estuary Fringe as a % of Forest Land Acres in Beach/Estuary Fringe	0%	2.4%	3.3%	1.2%	0.4%
Projected Young-growth harvest in RMAs outside of TTRA Buffers (acres)	0	26,030	0	0	882
Projected Young-growth Harvest in RMAs as a % of Forest Land Acres in RMAs	0%	6.7%	0%	0%	0.3%

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APPENDIX E
INTERAGENCY OLD GROWTH RESERVE REVIEW

Interagency Old Growth Reserve Review
Sealaska Land Conveyance
September 2015

Meeting date: Craig Ranger District, February 3-5, 2015

Attendees: Steve Brockmann (USFWS), Steve Bethune (ADF&G), Mark Minnillo (ADF&G); USFS: Brian Logan, Marla Dillman, Ray Slayton, Sally Burch, Lucy Maldonado (Day 1 only), Molly Simonson (note taker).

INTRODUCTION

The Sealaska Land Entitlement finalization of the Carl Levin and Howard P. 'Buck' McKeon National Defense Authorization Act for Fiscal Year 2015 conveyed 69,585 acres of Tongass National Forest lands to Sealaska Corporation to fulfill the commitment in the Alaska Native Claims Settlement Act. Included in these acres are areas that are designated as Old Growth Reserves (OGRs) in the 2008 Tongass Land and Resource Management Plan (Forest Plan). All of the OGRs reduced by the conveyance addressed here are on Prince of Wales Island and two smaller islands to the west.

On February 3, 2015 an interagency review team (IRT) met to develop a biologically preferred option for OGRs that meets Forest Plan Appendix K criteria and to document why other proposals are not recommended. The IRT was comprised of biologists from the U.S. Fish and Wildlife Service (USFWS), the Alaska Department of Fish and Game (ADF&G), and the U. S. Forest Service (USFS) who met in Thorne Bay to review the small OGRs affected by the land conveyance.

This meeting addressed how small OGRs have been affected by the Sealaska Land Entitlement finalization. The IRT came up with an interagency recommendation (biologically preferred location IOGRs) for each small OGR affected and one medium OGR.

The 2008 Forest Plan uses Land Use Designations (LUD) to guide the management of NFS lands within the Tongass. Each designation provides for a unique combination of activities, practices and uses. LUD II areas are congressionally designated areas in a roadless state to retain the wildland character. Wildlife and fish habitat improvement and primitive recreational facility development may be permitted. Timber harvesting is limited to insect and disease control. Roads will not be built except to serve mining and other authorized activities and vital Forest transportation and utility system linkages. LUD IIs are also designated as large OGRs. Large OGRs have not been reviewed since 1997. Some of the LUD IIs changed as a result of the land conveyance. The 2008 Forest Plan defines LUD II as Congressionally designated areas that should be managed in a roadless state to retain the wildland character. Wildlife and fish habitat improvement and primitive recreational facility development may be permitted. Timber harvesting is limited to insect and disease control. Roads will not be built except to serve mining and other authorized activities and vital Forest transportation and utility system linkages.

Our process was to look at large and medium OGRs and then move on to small OGRs.

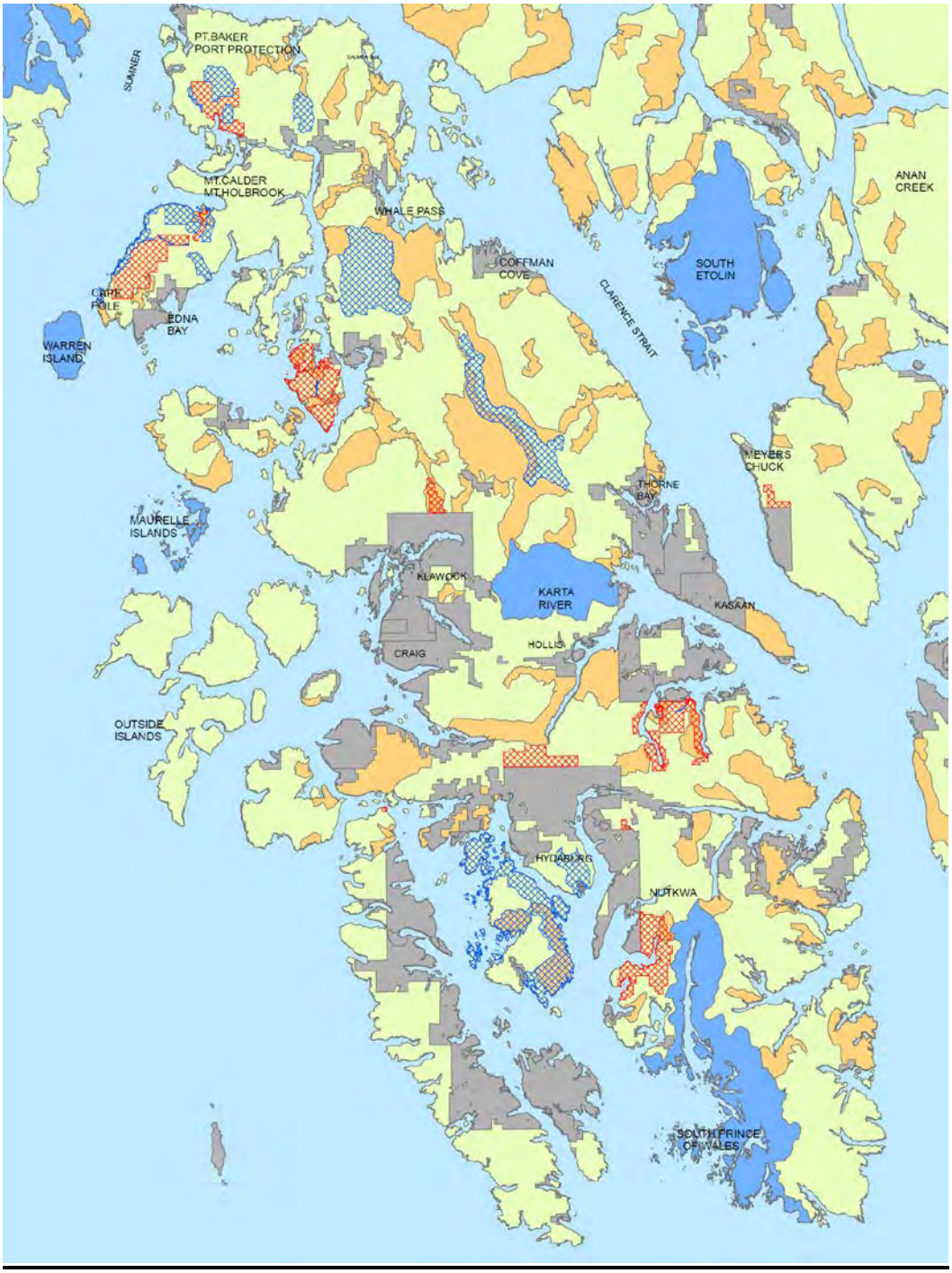
The land conveyance directly affected OGRs on POW, and neighboring islands) in VCUs 5450,

5460, 5560, 5570, 5600, 5872, 5900, 5940, 6180, 6190, 6200, and 6850 (see map 1).

This document will discuss the effects to the VCUs listed above as well as OGRs in VCUs that were indirectly impacted by the land conveyance; most of these VCUs involve the medium OGR. These VCUs include 6160, 6170, 6750 and 6760.

VCUs 5450, 5460 are on Kosciusko Island; 5560, 5570, 5600 and 5872 are on Tuxekan Island; while 5900 and 5940 (Election Creek); 6180, and 6190 were a medium OGR in the Old Thom's Research Natural Area; 6200 (Dog Salmon) and 6850 (Nutkwa) are all Prince of Wales Island.

The 2015 Interagency review team proposal for the medium also affects VCUs 6160, 6170, 6750 and 6760.



Map 1

Conservation Strategy

Small OGRs were analyzed extensively during the 2008 Forest Plan Amendment process (USFS 2008), and many were modified. This review is discussed as the 2006 IRT. The Forest Plan allows line officers to further modify the size and location of OGRs under certain circumstances (Forest Plan Appendix K). Modifications of small OGRs require an interagency review to ensure that OGRs meet Forest Plan criteria. Alternative locations for OGRs "must provide comparable achievement of Old–growth Habitat LUD goals and objectives" (Forest Plan, p. 3-57 and 3-62).

Goals

- Maintain areas of old-growth forests and their associated natural ecological processes to provide habitat for old-growth associated resources.
- Manage early seral conifer stands to achieve old-growth forest characteristic structure and composition based upon site capability. Use old growth definitions as outlined in Ecological Definitions for Old-growth Forest Types in Southeast Alaska (R10-TP-28).

Objectives

- Provide old-growth forest habitats, in combination with other LUDs, to maintain viable populations of native and desired non-native fish and wildlife species and subspecies that may be closely associated with old-growth forests.
- Contribute to the habitat capability of fish and wildlife resources to support sustainable human subsistence and recreational uses.
- Maintain components of flora and fauna biodiversity and ecological processes associated with old-growth forests.
- Allow existing natural or previously harvested early seral conifer stands to evolve naturally to old-growth forest habitats, or apply silvicultural treatments to accelerate forest succession to achieve old-growth forest structural features. Consider practices such as thinning, release and weeding, pruning, and fertilization to promote accelerated development of old-growth characteristics.
- To the extent feasible, limit roads, facilities, and permitted uses to those compatible with old-growth forest habitat management objectives.
- Significant modifications to OGRs (e.g. a land conveyance or substantial timber harvest) require consideration and review of factors such as connectivity, size, and shape of the reserve, as well as the basic assumptions behind the existing reserve location.

Pursuant to Forest Plan Appendix K, OGR boundary changes require an interagency team of USDA Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and Alaska Department of Fish and Game (ADF&G) biologists to jointly evaluate the location and habitat composition of the OGRs by reviewing such things as productive old growth (POG) blocks within a VCU.

One goal of the Forest Plan is to maintain healthy forest ecosystems with a mix of habitats at different spatial scales capable of supporting the full range of naturally occurring flora, fauna, and ecological processes characteristic of Southeast Alaska. To accomplish this goal, an old-growth habitat conservation strategy was incorporated into the Forest Plan. This strategy consists of two components. The first is a forest-wide system of old-growth reserves (OGRs) comprised of lands classified by the Forest Plan as non-development land use designations (LUDs). These LUDs include, among others, Wilderness, Wilderness National Monument, Remote and Semi-Remote Recreation, Wild Rivers, Municipal Watersheds, and Old-growth Habitat LUDs. The Old-growth Habitat LUD is further subdivided into small, medium, and large old-growth

reserves. The second component of the old-growth strategy is the set of standards and guidelines for habitats that occur within the "matrix" or lands outside of the non-development LUDs.

OGR Criteria

The Forest Plan Appendix K and 2008 Forest Plan FEIS Appendix D describe the requirements for OGRs in detail. Primary OGR habitat criteria are summarized below. OGR calculations are based on the acres of National Forest Service lands within the VCU.

- Small OGRs should encompass a contiguous landscape representing at least 16 percent of each VCU with at least 50 percent of that area in productive old growth (POG). The preferred biological objective is for each small OGR to contain at least 800 acres of POG.
- OGRs must contain a minimum of 400 acres of POG.
- Where VCU boundaries do not match watershed or ecological boundaries, up to 30 percent of the OGR may be mapped in an adjacent VCU if the OGR objectives are met.
- VCUs that are separated by saltwater channels, reserves may be separated, but attempt to retain 800 acres of productive old growth in each.
- OGR boundaries should follow recognizable features that are identifiable on the ground such as streams, roads, distinctive ridges, watershed boundaries, or v-notches.
- OGRs should be located so that spacing is maintained in the four cardinal directions.
- Reserves should be more circular rather than linear to maximize the amount of interior forest habitat.
- The amount of early seral habitat (young growth) and roads should be minimized within the OGRs.
- Existing large blocks of contiguous high-volume old-growth forest should not be further fragmented by timber harvesting or road building.
- Incorporate wider corridors. Designed corridors should be of sufficient width to minimize edge effect and provide interior forest conditions.
- Do not differentially cut low altitude, high-volume old growth [represented by marten winter habitat: high-POG ≤800 feet elevation]
- Site-specific factors in placing reserves should be considered to help meet multiple biodiversity or wildlife habitat objectives. Factors include, but are not limited to:
    1. The largest remaining blocks of contiguous old growth within a watershed. Old-growth forest that constitutes scattered fragments of unsuitable timberland generally did not contribute to meeting small reserve design.
    2. Rare features such as underrepresented forest plant associations or stands with some of the Forest's highest volume timber stands (defined as high-POG and particularly SD67).
    3. Known or suspected goshawk nesting habitat (defined as high-POG <1000 feet elevation).
    4. Known or suspected marbled murrelet nesting habitat. [Represented by large tree SD67]
    5. Important deer winter range to maintain important deer habitat capability to meet public demand for use of the deer resource (defined as high-POG <800 feet elevation

on south and west aspects for deep snow habitat and POG <1500 feet elevation for average winter habitat).

Other Forest Plan Direction

Forest Plan Management Prescriptions for Old-growth Habitat (Forest Plan FEIS p. 3-62)

- During project-level environmental analysis, for projects areas that include or are adjacent to mapped old-growth habitat reserves, the size, spacing, and habitat composition of mapped reserves may be further evaluated (See Appendix K for mapping criteria.)
- Adjust reserves not meeting the minimum criteria to meet or exceed the minimum criteria. Reserve location, composition, and size may otherwise also be adjusted.
- Alternative reserves must provide comparable achievement of the Old-growth Habitat LUD goals and objectives. Determination as to comparability must consider the criteria listed in Appendix K.
- Adjustments to individual reserves are not expected to require a significant plan amendment. Adjustments Forest-wide shall be monitored yearly to assess whether a significant plan amendment is warranted on the basis of cumulative changes.

Forest-wide Standards and Guidelines for Landscape Connectivity (Forest Plan p. 4-91):

Design projects to maintain landscape connectivity. The objective is to maintain corridors of old-growth forest among large and medium Old-growth Habitat reserves (Appendix K) and other Non-development LUDs at the landscape scale. Review forest connectivity within and between OGRs and non-development LUDs during environmental review of projects proposing timber harvest, road construction, or other significant vegetation alteration. Where existing corridors are insufficient or vulnerable to harvest, stands of POG should be provided as corridors or small reserves should be relocated.

HISTORY OF THE OGRS

The following documents provide the history of OGRs:

Developmental and National Setting LUD's and VPOP (February 1997)
Forest Plan (1997)
Prince of Wales Island Interagency OGR Review Report (2002)
Final Forest Plan (2008) OGR spreadsheet (09_092909_OGR_Tracking_Table.xls)

Individual NEPA documents that included OGRs analysis:

Central Prince of Wales (CPOW) EIS (1993) -VCU 5542
Polk Inlet EIS (1995) - VCUs 6180, 6190 and 6200
Control Lake EIS (1998) -VCUs 5940, 5950 and 5960
Cholmondeley EIS (1998) -VCUs 6160, 6170, 6750 and 6760
Kosciusko DEIS (2002) -VCUs 5450 and 5460
Tuxekan Timber Sale DEIS (update 2004) – VCUs 5560, 5570, 5600 and 5872
Staney Timber Sale (TEAMS) (2005) –VCU 5900
Big Thorne EIS (2013) -VCU 5950

Not covered under any previous NEPA (except Forest Plan) – 6850

ANALYSIS OF THE OGRS

Past reviews of the small OGRs include the 2002 Review of the OGRs on Prince of Wales Island (2002 POW review team) and a 2006 Tongass wide review of the OGRs, including those on Prince of Wales, for the 2008 Forest Plan amendment (2006 IRT).

The goals of the 2015 IRT included:

- Review purpose, rational, and objectives used by previous interagency review teams for locating current OGRs;
- Identify biologically preferred OGR locations for OGRs located in VCUs 5450, 5460, 5560, 5570, 5600, 5872, 5900, 5940, 6180, 6190, 6200, and 6850.

ANALYSIS OF OGRS by VCU

Kosciusko Island

Pre-conveyance: During the 2006 OGR review for the 2008 Forest Plan amendment the designated OGRs in VCUs 5450 and 5460 were combined. All the OGR in VCU 5460 were counted towards the OGR in VCU 5450. The acres designated as a Special Interest Area (SA) LUD in VCU 5460 function and count as OGR acres in VCU 5460. The required amount of acres for a small OGR is met in VCU 5460 by the designation of an SA in this VCU under the 2008 Forest Plan. Both OGRs were modified to exclude units proposed in the Kosciusko Timber Sale. Acknowledge The IRT recommended that that Forest Road 1525225 which occurs within the OGR be closed.

Post Conveyance: On Kosciusko Island the Defense Authorization Act for 2015 conveyed almost 12,000 acres of National Forest land to the Sealaska Corporation. Nearly all of the acres were productive forest lands (11,161 acres) and the majority of these acres are young growth timber (7,328 acres).

The land conveyance minimally affected the currently designated small OGR boundaries in VCU 5450 and 5460. The conveyance removed a small portion of the OGR in VCU 5450 in the southwest corner and the OGR in VCU 5460 lost the small western finger.

VCU 5450 -Survey Cove

In the 1997 TLMP there were two disconnected OGRs in this VCU that are mapped as small OGRs (see Figure 1). The western OGR is overlap from and applies to VCU 5450.

Pre-conveyance: The 2002 POW review team relocated the 1997 TLMP small OGR to increase POG acres because the 1997 TLMP OGR was mostly muskeg. The 2002 POW review team proposal expanded the OGR to the south and northeast to pick up POG acres. Since there is not enough POG remaining in this VCU the 2002 POW review team expanded the OGR into adjacent VCU 5460. This OGR was linear, contained second growth, roads, and higher elevation stands. The OGR did not include preferred habitat but it did include the only remaining habitat.

2006 IRT recommended adopting the 2002 POW review team OGR. The proposed 2006 IRT OGR in VCU 5450 overlaps into VCU 5460.

The 2006 IDT noted that the 2006 IRT OGR (that was originally proposed by the 2002 POW review team) included units in the Kosciusko Timber Sale and modified the IOGR to exclude these units. A project level review was recommended to consider adding second growth habitat to make the OGR more circular.

Post Conveyance: The conveyance removed a small southwest portion of the OGR in VCU 5450. The land conveyance resulted in the removal of 68 acres from the OGR in VCU 5450; 53 of these acres were POG. The resulting OGR still meets minimum Forest Plan acre and POG acre requirements.

2015 IOGR Rationale/Notes: This VCU has been heavily impacted by past harvest. There are no large contiguous blocks of POG left in VCU 5450. In order to replace the acres of POG lost due to the land conveyance the 2015 IRT proposes adding acres from adjacent VCU 5460. The block of POG added from VCU 5460 is one of the largest remaining patches of contiguous old growth in that VCU. The 2015 IRT proposal also adds acres and POG acres to the OGR in VCU 5450 from the adjacent VCU (5460) to try to compensate for the overall loss of POG in VCU 5450. Adding the acres from VCU 5460 to the proposed 2015 biologically preferred OGR also helps to maintain connectivity through the central portion of south Kosciusko Island; this is especially important at the landscape scale when considering that this area is now surrounded by lands in other ownerships. The 2015 IRT proposal would add 1260 total acres and 904 acres of POG to the OGR. As a result of these additional acres the 2015 IRT OGR would exceeds both the minimum acre requirements and the POG acres requirements. The 2015 IRT felt this was necessary given the amount of past harvest in the area, the current lack of remaining POG and lack of connectivity in this portion of Kosciusko Island (see Figure 1).

Comparison of Small OGR in VCU 5450

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	10,764		
Non-NFS land (acres)	3,109	6,249	6,249
NFS land Total (acres)	7,655	4,515	4,515
16% of NFS land (Min. Req. OGR acres)	1,211	722	722
All Non-development LUD in VCU	1,993	1,917	1,994
Small OGR (total acres)[1/]	1,454	1,386	2,652[1/]
8% of NFS land (Min. POG Req. acres)	605	361	361
OGR POG (total acres)[2/]	867	814	1,718
All Non-development POG (acres)	1,267	1,220	1,468
Acreage requirements met? (Total/POG)	Yes/Yes	Yes/Yes	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU 5460			
Total OGR Acres	266	260	1,448
OGR POG Acres	266	260	1,159
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	Yes	Yes
Minimizes roads (total road miles)	3.9	3.9	4.8
Includes streams (Class I stream miles)	0.0	0.0	6.2
Minimizes early seral habitat (acres)	293	293	463
Includes largest remaining block of POG in VCU?	No	No	Yes
Rare/Underrepresented features (large tree POG acres) [3/]	499	453	1,016
Deep snow deer/marten habitat (acres) [4/]	297	271	742
Goshawk and murrelet nesting habitat (acres) [5/]	703	656	1,273
Other Considerations			
Maintains Connectivity	No	No	Yes
Low elevation POG (acres)[6/]	423	391	1,150

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types; see Issue 3)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 5460 -Edna Bay

Pre Conveyance: In the 1997 TLMP there were two disconnected areas in this VCU that were both designated as small OGRs (see Figure 1). The western OGR was overlap from and applies to the OGR in VCU 5450. The eastern OGR counted towards the OGR in this VCU (5460). The acres in the western OGR that count towards the OGR in VCU 5450 are discussed above under that VCU.

Since eastern OGR was short total acres the 2006 IRT recommended expanding it to the north to create a more circular reserve and form a connection with the low elevation pass between Van Sant Creek and Trout Creek (in VCU 5430), where evidence of high deer use has been observed. This OGR includes the high vulnerability karst on west side of Van Sant Creek and a portion of the POG remaining at Van Sant Cove. The 2006 IRT recommended prioritizing second growth included in the OGR for thinning.

The 2006 IRT IOGR included units proposed in the Kosciusko Timber Sale. The 2006 IRT responded that it was preferable that the IOGR maintain the travel corridor/pass located on the east side of the VCU. The modified the IOGR excluded the Kosciusko Timber Sale units but maintains the low elevation east-west travel corridor/pass between Van Sant Creek and Trout Creek (in VCU 5430). The 2006 team recommended that Forest Service Road 1525225 be closed.

For the 2008 Forest Plan the eastern OGR designation was changed from small OGR to SA; the boundary of the OGR was not changed. The acres now designated as SA count and function as the OGR in this VCU. A portion of this SA overlaps into adjacent VCU 5430. The contiguous acres of this SA in VCU 5430 also count towards the OGR in VCU 5460. There is another non-contiguous SA in VCU 5430 that functions as the OGR for VCU 5430

Post conveyance: The land conveyance resulted in the loss of the western finger of the western OGR in this VCU; however these acres count towards the OGR in VCU 5450. The land conveyance also changed the area that was designated as SA to a LUD II designation. The boundaries of the SA/LUD II area were not changed (see Figure 1).

2015 IOGR Rationale/Notes: For 2015 IRT comments on the affects to the western OGR see discussion under VCU 5450 above.

Under the 2008 Forest Plan the SA in VCU 5460 functioned as the OGR in this VCU. As part of the defense bill the SA LUD in VCU 5460 was converted to a LUD II which the 2015 IRT believes meets the intent of and functions as an OGR in this VCU. The minimum acreage criteria and POG acres required for a small OGR are met by the LUD II area. Therefore no changes are recommended and no additional acres are required for this SA/LUD II/OGR.

Acreage differences in this OGR/SA/LUD II shown in the comparison table between pre conveyance and post conveyance are due to GIS edits, no changes were made to the boundary (see Figure 1).

Comparison of Small OGR in VCU 5460*

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	14,655		
Non-NFS land (acres)	4,055	5,326	5,326
NFS land Total (acres)	10,600	9,329	9,329
16% of NFS land (Min. Req. OGR acres)	1,697	1,493	1,493
All Non-development LUD in VCU	1,508	1,501	1,501
Small OGR (total acres)[1/]	0	1, 656	1, 656
8% of NFS land (Min. POG Req. acres)	849	746	746
OGR POG (total acres)[2/]	0	1,167	1,167
All Non-development POG (acres)	1,214	1,207	1,207
Acreage requirements met? (Total/POG)	Yes/Yes	Yes/Yes	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU 5430			
Total OGR Acres	519	519	519
OGR POG Acres	305	305	305
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	No	No	No
Minimizes roads (total road miles)	3.2	3.2	3.2
Includes streams (Class I stream miles)	0.6	0.6	0.6
Minimizes early seral habitat (acres)	360	360	360
Includes largest remaining block of POG in VCU?	Yes	Yes	Yes
Rare/Underrepresented features (large tree POG acres) [3/]	935	935	935
Deep snow deer/marten habitat (acres) [4/]	494	494	494
Goshawk and murrelet nesting habitat (acres) [5/]	1,068	1,068	1,068
Other Considerations			
Maintains Connectivity	Yes	Yes	Yes
Low elevation POG (acres)[6/]	561	561	561

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)
*Acreage differences between pre and post conveyance due to GIS map edits and not boundary changes

Sealaska Land Conveyance effect to SA/OGR in VCU 5410 with ROW at Shipley Bay

There are no mapped OGR acres in this VCU; all acres are mapped as SA or LUD II acres. The SA in this VCU is in two separate pieces. The northwestern piece functions as the OGR for VCU 5430. This piece was originally contiguous with the large Mt Calder-Mt Holbrook LUD II; however due to the land conveyance Sealaska now has a road right of way (ROW) through here to potentially connect to the old LTF/MAF in Shipley Bay. As a result of the ROW the portion of the OGR/LUD II in VCU 5430 is now disconnected from the large Mt Calder –Mt Holbrook LUD II area (see Figure 1).

These acres in the northwestern mapped SA/OGR in VCU 5430 are contiguous with the western OGR/SA acres in VCU 5410. Combining the northern SA/OGR in VCU 5430 (4,669 acres) with the western portion of SA/OGR in VCU 5410 (3,234 acres) for a total of 7,933 acres. The POG acres when these two areas are combined equal 6,008 acres. The small OGR requirements for this VCU are at least 2,522 acres with 1,261 acres of POG (without the reduction in required acres in the OGR due to the overall loss of Forest Service acres in the VCU). The Sealaska land conveyance resulted in a portion of the SA/OGR in this VCU being disconnected to the Mt Calder-Mt Holbrook LUD II area; however, despite loss of the connectivity between the OGR/LUD II in VCU 5430, the area still has adequate protected habitat to meet minimum small OGR requirements in this VCU. The 2015 IRT recommends no additional OGR designations in this VCU.

VCUs 5450 and 5460 and Right of Way in VCU 5410

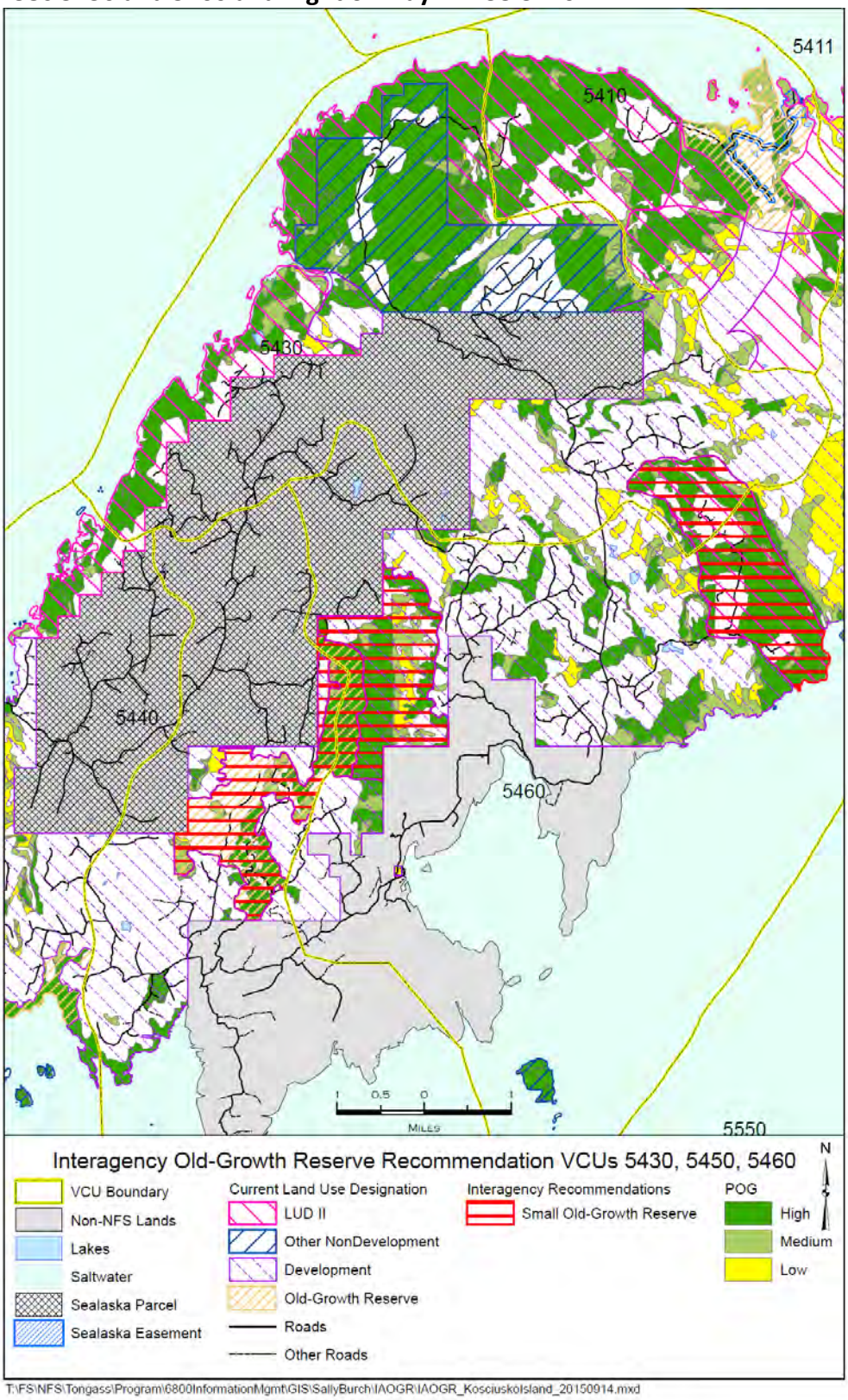


Figure 1

Tuxekan Island

VCU 5560 -Northwest Tuxekan

Pre Conveyance: The 2006 IRT proposed to adopt the POW 2002 Review and Tuxekan Timber Sale Draft ROD proposal to relocate 1997 Forest Plan small OGR. This proposal added the largest remaining block of POG that includes south-facing slopes, high value deer winter range, and goshawk and murrelet nesting habitat. This proposal increased total acres in the OGR and includes some young growth acres.

The 2008 Forest Plan Amendment reduced the size of the small OGR to meet minimum acre criteria but retained the largest remaining block of POG, south-facing slopes, high value deer winter range, and potential goshawk and murrelet nesting habitat.

The OG LUD was added to this VCU because while the non-development LUD acres in this VCU meet the acre criteria for a small OGR these acres occur on a series of small islands and not on Tuxekan Island.

Post Conveyance: Most of the land in this VCU is now in Sealaska ownership including the entire area that was designated as small OGR in this VCU. The remaining acres of non-development LUD in this VCU are on small islands mostly to the north of Tuxekan Island. These acres of non-development meet the Forest Plan minimum acres requirements for a small OGR.

2015 IOGR Rationale/Notes: Most of the remaining Forest Service acreage in VCU 5560 is on El Cap Island and other small, isolated, non-timbered islands. There is only one substantial block of POG in Forest Service ownership left in this VCU on Tuxekan Island. The 2015 IRT recommends that this block be included in the OGR. Most of the block of POG is within the beach buffer and therefore low elevation POG. The 2015 IRT recommends that the OGR in this VCU connect with the OGR in VCU 5570 to maintain this block. The 2015 IOGR proposal in VCU 5560 is contiguous with the 2015 IOGR proposal in VCU 5570. These two OGRs provide some connectivity between Tuxekan Island and mainland POW via a saltwater channel (see Figure 2).

Comparison of Small OGR in VCU 5560

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	6,789		
Non-NFS land (acres)	843	4,359	4,359
NFS land Total (acres)	5,946	2,430	2,430
16% of NFS land (Min. Req. OGR acres)	951	374	374
All Non-development LUD in VCU	3,055	1,866	2,321
Small OGR (total acres)[1/]	1,016	0	455
8% of NFS land (Min. POG Req. acres)	476	187	187
OGR POG (total acres)[2/]	882	0	378
All-Non-development LUD POG (acres)	2,167	1,229	1,609
Acreage requirements met? (Total/POG)	Yes/Yes	No/No	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU	NA	NA	NA
Total OGR Acres			
OGR POG Acres			
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	No	Yes
Minimizes roads (total road miles)	1.6	0.0	0.0
Includes streams (Class I stream miles)	4.2	0	0.6
Minimizes early seral habitat (acres)	0	0	57
Includes largest remaining block of POG in VCU?	Yes	No	Yes
Rare/Underrepresented features (large tree POG acres) [3/]	361	0	331
Deep snow deer/marten habitat (acres) [4/]	418	0	363
Goshawk and murrelet nesting habitat (acres) [5/]	418	0	363
Other Considerations			
Maintains Connectivity	Yes	No	Yes
Low elevation POG (acres)[6/]	882	0	381

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 5570 -Northeast Tuxekan

VCU 5570 is separated by a saltwater channel with a portion of the VCU on Tuxekan Island and part on Prince of Wales Island.

Pre conveyance: The OGR in VCU 5570 overlaps into both VCU 5560 and VCU 5600. This overlap is not required to meet acre criteria but to follow recognizable features. The 2006 IRT adopted the 2006 Tuxekan Timber Sale Draft ROD OGR that relocated the small OGR to increase POG, maintain low elevation habitat, deer winter range, murrelet nest, and potential goshawk nesting habitat. The 2006 IRT OGR was adopted in the 2008 Forest Plan.

Post Conveyance: The Sealaska land conveyance resulted in the loss of most the acres designated as small OGR in this VCU. The remaining acres of OGR are now isolated and surrounded by lands in other ownership.

2015 IOGR Rationale/Notes: The 2015 IRT recommends replacing the acres remaining in the existing small OGR on Tuxekan with acres on the northern tip of the island adjacent to the 2015 IRT proposed OGR in VCU 5560 (see Figure 2). The intent of these acres is to provide connectivity between the large LUD II area around Sarkar Lake in VCUs 5541 and 5542 (on POW mainland) and the IRT proposed small OGR in VCU 5560 (on Tuxekan). The connectivity factor is of higher importance than trying to exclude the second growth that occurs within the 2015 IRT proposed OGR. The 2015 IRT recommends selecting an area, mostly beach buffer, which is across the saltwater channel on mainland POW. Most of these proposed acres on mainland POW are still in VCU 5570; however in order to provide compete connectivity to the large LUD II area acres in VCU 5542 were also included. These acres across the channel would extend from just south of Dargon Point north to Kahli Cove. Even though these two areas are separated by a saltwater channel they will contribute to the connectivity across to mainland POW. The saltwater channel is at the most about 1 mile across; however this channel is interspersed with many smaller islands which would facilitate dispersal. By selecting the acres on mainland POW connectivity is improved between Tuxekan Island and the large LUD II area around Sarkar Lake. This LUD II area is then connected to other OGRs and LUD II areas on POW.

Comparison of Small OGR in VCU 5570

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	8,520		
Non-NFS land (acres)	1,487	3,812	3,812
NFS land Total (acres)	7,033	4,708	4,708
16% of NFS land (Min. Req. OGR acres)	1,128	738	738
All Non-development LUD in VCU	1,556	737	2,304
Small OGR (total acres)[1/]	1,309	328	1,566
8% of NFS land (Min. POG Req. acres)	564	369	369
OGR POG (total acres)[2/]	884	280	810
All Non-development LUD POG (acres)	4,097	576	1,328
Acreage requirements met? (Total/POG)	Yes/Yes	No/No	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU 5560			
Total OGR Acres	103	0	0
OGR POG Acres	55	0	0
Small OGR LUD Overlap into Adjacent VCU			
VCU 5600			
Total Acres	93	0	0
POG Acres	62	0	0
Small OGR LUD Overlap into Adjacent VCU			
VCU 5542			
Total Acres	0	0	70
POG Acres	0	0	58
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	No	Yes
Minimizes roads (total road miles)	3.4	0.4	4.4
Includes streams (Class I stream miles)	4.0	0.6	2.6
Minimizes early seral habitat (acres)	9	9	734
Includes largest remaining block of POG in VCU?	Yes	No	Yes
Rare/Underrepresented features (large tree POG acres) [3/]	444	66	432
Deep snow deer/marten habitat (acres) [4/]	567	102	666
Goshawk and murrelet nesting habitat (acres) [5/]	567	102	666
Other Considerations			
Maintains Connectivity	Yes	No	Yes
Low elevation POG (acres)[6/]	884	280	810

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 5600 -Southwest Tuxekan

Pre Conveyance: The 2006 IRT proposed to adopt the 2002 POW IRT and Tuxekan Timber Sale Draft ROD that modified the small OGR to increase acres to meet total and POG acre requirements; include both deer winter range and the largest contiguous block of POG, as well as the low elevation pass between the east fork of Karheen Creek and the large lake in VCU 5800. This modified OGR also follows recognizable features and improves connectivity. The OGR is linear in shape because VCU is fragmented by past harvest. The OGR was designed to include remaining POG and maintain connectivity.

Post Conveyance: Due to the Sealaska land conveyance there is very little Forest Service land remaining in this VCU. Conveyance reduces connectivity between OGRs in VCUs 5600 and 5872, which were linear spanning Tuxekan Island.

2015 IOGR Rationale/Notes: The Sealaska land conveyance results in little National Forest Service (NFS) land remaining in this VCU. The 2015 IRT suggested OGR includes most of the remaining NFS land in the VCU and as a result exceeds the 16 percent of NFS land in the VCU requirement in the Forest Plan (see Figure 2). Biologically Preferred OGR enhances connectivity to the beach.

Comparison of OGR in VCU 5600

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	6,026		
Non-NFS land (acres)	2	5,264	5,264
NFS land Total (acres)	6,024	762	762
16% of NFS land (Min. Req. OGR acres)	964	122	122
All Non-development LUD in VCU	1,213	563	761
Small OGR (total acres)[1/]	1,059	556	755
8% of NFS land (Min. POG Req. acres)	482	61	61
OGR POG (total acres)[2/]	788	373	526
All Non-development LUD POG (acres)	861	373	526
Acreage requirements met? (Total/POG)	Yes/Yes	Yes/Yes	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU	NA	NA	NA
Total OGR Acres			
OGR POG Acres			
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	No	No	Yes
Minimizes roads (total road miles)	0.9	0.0	0.0
Includes streams (Class I stream miles)	5.2	3.8	4.8
Minimizes early seral habitat (acres)	0	0	21
Includes largest remaining block of POG in VCU?	No	No	No
Rare/Underrepresented features (large tree POG acres) [3/]	382	95	116
Deep snow deer/marten habitat (acres) [4/]	474	165	299
Goshawk and murrelet nesting habitat (acres) [5/]	506	165	299
Other Considerations			
Maintains Connectivity	Yes	No	Yes
Low elevation POG (acres)[6/]	756	373	526

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 5872 -Southeast Tuxekan

Pre Conveyance: The 2006 IRT recommended adopting the past interagency proposal and Tuxekan Timber Sale Draft ROD that recommended relocating the small OGR to include the largest remaining block of POG and increase deer winter range.

Post Conveyance: Due to the Sealaska land conveyance there is very little Forest Service land remaining in this VCU. The 2015 IRT suggested OGR includes most of the remaining NFS land in the VCU and as a result exceeds the 16 percent of NFS land in the VCU requirement in the Forest Plan.

2015 IOGR Rationale/Notes: The 2015 IRT recommend the 1997 TLMP OGR boundary with some modifications (see Figure 3). Nichen Cove on Tuxekan Island has human impacts and activities (log transfer facility and roads etc.). The 2015 IRT determined that it was less important to include the Nichen Cove area in the OGR as one criterion is to reduce road miles in an OGR.

The conveyance eliminates connectivity with the small OGR in VCU 5600 (see Figure 2). The Biologically Preferred OGR adds connectivity to the beach.

Comparison of Small OGR in VCU 5872

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	3,310		
Non-NFS land (acres)	0	2,087	2,087
NFS land Total (acres)	3,310	1,223	1,223
16% of NFS land (Min. Req. OGR acres)	530	196	196
All Non-development LUD in VCU	553	228	858
Small OGR (total acres)[1/]	536	227	857
8% of NFS land (Min. POG Req. acres)	265	98	98
OGR POG (total acres)[2/]	501	219	474
All Non-development LUD POG (acres)	501	219	474
Acreage requirements met? (Total/POG)	Yes/Yes	Yes/Yes	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU	NA	NA	NA
Total OGR Acres			
OGR POG Acres			
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	No	Yes
Minimizes roads (total road miles)	1.8	0.0	0.0
Includes streams (Class I stream miles)	0.7	0.5	3.5
Minimizes early seral habitat (acres)	1	1	5
Includes largest remaining block of POG in VCU?	Yes	No	Yes
Rare/Underrepresented features (large tree POG acres) [3/]	293	32	36
Deep snow deer/marten habitat (acres) [4/]	295	36	51
Goshawk and murrelet nesting habitat (acres) [5/]	314	36	51
Other Considerations			
Maintains Connectivity	Yes	No	Yes
Low elevation POG (acres)[6/]	482	219	474

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 5560, 5570, 5600 and 5872

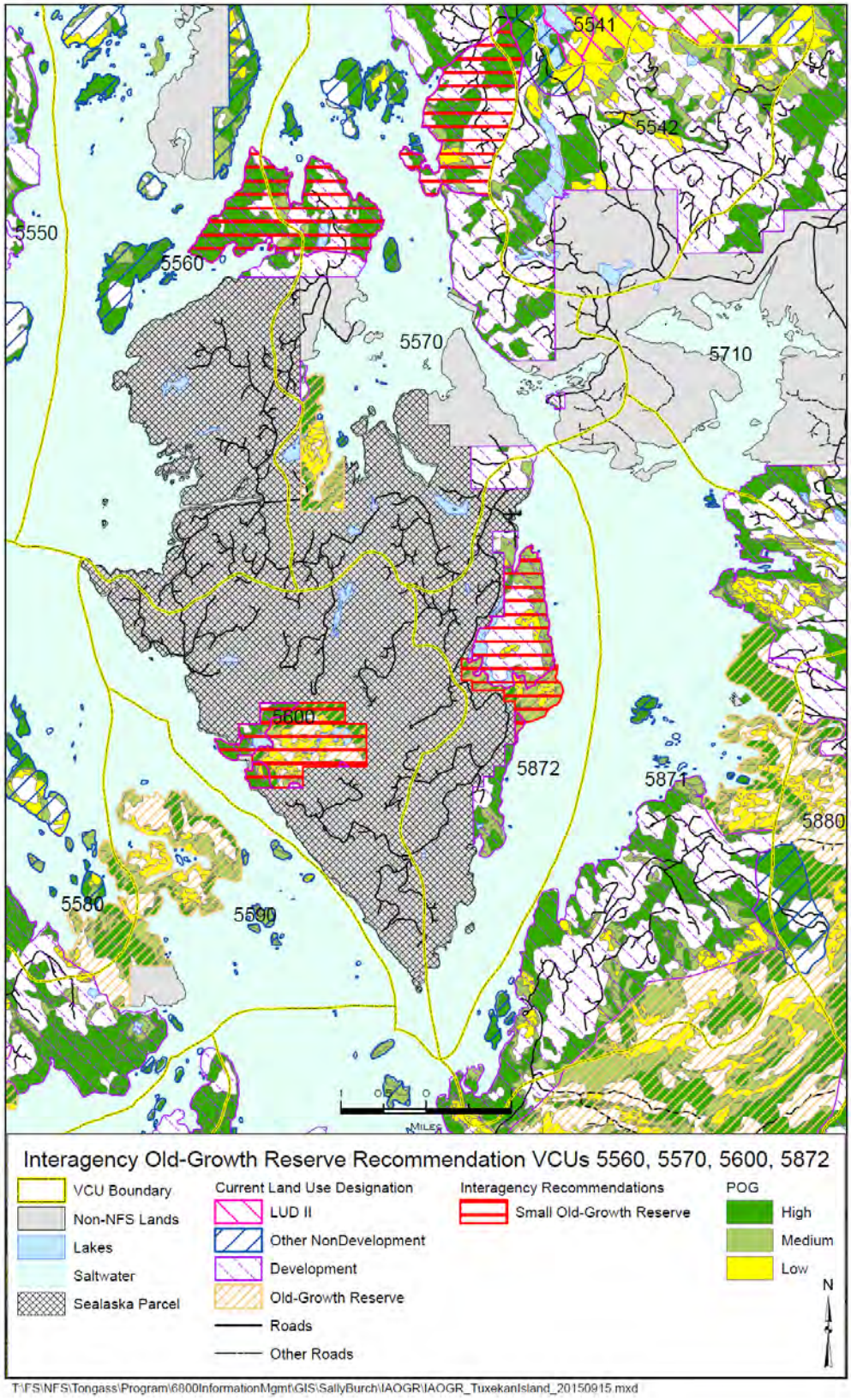


Figure 2

VCU 5940 -Election Creek

Pre-Conveyance: During the 2006 review it was proposed to revert to the 1997 TLMP OGR to exclude contracted Timber Sale units. The 2006 IRT proposed to add an area east of the 1997 TLMP OGR to maintain connectivity.

A project level review was recommended because the 2006 IDT Forest Plan proposed OGR did not maintain east/west connectivity. Although the proposed OGR does maintain the largest contiguous block of POG and north/south connectivity, it is important to also maintain east/west connectivity in the area because of the amount of past harvest that has occurred in this area.

Post Conveyance: The land conveyance resulted in the loss of the largest contiguous block of POG as well as connectivity between VCU 5940 and VCU 5900 (north/south connectivity). The connectivity between VCUs 5940 and 5900 provided connectivity between the OGR in VCU 5940 and OGRs in VCUs to the north.

2015 IOGR Rationale/Notes: Most of the existing small OGR in this VCU was conveyed to Sealaska. The 2015 IRT proposes that the small remaining portion of the original OGR along the western edge of the land conveyance be dropped. The 2015 IRT proposed the small portion along the eastern edge of the Sealaska land conveyance be kept and expanded to the east to the VCU line with VCU 5950 to connect with the current OGR that exists in VCU 5950 (see Figure 3). This will provide the east/west connectivity mentioned in the 2006 review. This connectivity will help to compensate for the loss of the north/south connectivity lost due to the land conveyance.

The 2015 IRT proposed OGR in VCU 5940 is short both total and POG acres; however the IRT determined that this was acceptable due to the fact that the proposed OGR is adjacent to the IRT proposed OGR in VCU 5950 and the connectivity that the placement of the OGR here provides. The OGR in VCU 5950 connects to the large Honker OGR complex via roadless. The 2015 IRT OGR includes all remaining acres in this VCU east of the land conveyance; any additional acres in this VCU would be separated by Sealaska land.

The conveyance splits this small OGR. The Biologically Preferred alternative maintains connectivity to small OGRs in VCUs 5900 and 5950 (see Figure 3).

Comparison of Small OGR in VCU 5940

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	33,334		
Non-NFS land (acres)	15,737	17,587	17,587
NFS land Total (acres)	17,597	15,747	15,747
16% of NFS land (Min. Req. OGR acres)	2,816	2,520	2,520
All Non-development LUD in VCU	2,770	1,072	1,952
Small OGR (total acres)[1/]	2,270	1,072	1,499
8% of NFS land (Min. POG Req. acres)	1,408	1,260	1,260
OGR POG (total acres)[2/]	1,824	438	607
All Non-development LUD POG (acres)	1,824	438	805
Acreage requirements met? (Total/POG)	No/Yes	No/No	No/No*
Small OGR LUD Overlap into Adjacent VCU			
VCU	NA	NA	NA
Total OGR Acres			
OGR POG Acres			
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	No	No
Minimizes roads (total road miles)	3.9	1.2	1.2
Includes streams (Class I stream miles)	5.3	0.2	0.2
Minimizes early seral habitat (acres)	83	83	90
Includes largest remaining block of POG in VCU?	Yes	No	No
Rare/Underrepresented features (large tree POG acres) [3/]	735	71	71
Deep snow deer/marten habitat (acres) [4/]	786	32	53
Goshawk and murrelet nesting habitat (acres) [5/]	1,344	243	203
Other Considerations			
Maintains Connectivity	NA	No	Yes
Low elevation POG (acres)[6/]	945	65	125

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)
*See discussion for this VCU and VCU 5950

VCU 5950 -Big Salt

The land conveyance did not impact the OGR in this VCU directly; however, the 2015 IRT proposes expanding the OGR in this VCU to the north and west (see Figure 3). The 2015 IRT also proposes an expansion of the current OGR to the southeast to include an area of contiguous high volume POG (HPOG). This additional HPOG in VCU 5950 helps to compensate for loss of high volume POG in VCU 5940. This area of HPOG in VCU 5950 is currently mapped as roadless.

The existing 2008 Forest Plan OGR in VCU 5950 was modified under the Big Thorne EIS. The current proposed 2015 IRT expansions avoid Big Thorne units.

The east/west connectivity that this OGR modification helps to provide includes a connection with currently mapped roadless acres in VCU 5950 that then connects to the OGR in VCU 5960 which is included as part of the large Honker OGR complex (OG LUD designated areas as well as other non-development LUDs).

Comparison of Small OGR in VCU 5950

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	21,465		
Non-NFS land (acres)	3,741	3,741	3,741
NFS land Total (acres)	17,724	17,724	17,724
16% of NFS land (Min. Req. OGR acres)	2,836	2,836	2,836
All Non-development LUD in VCU	4,230	4,230	5,215
Small OGR (total acres)[1/]	2,037	2,037	3,567
8% of NFS land (Min. POG Req. acres)	1,418	1,418	1,418
OGR POG (total acres)[2/]	1,261	1,261	1,969
All Non-development LUD POG (acres)	2,161	2,161	2,694
Acreage requirements met? (Total/POG)	No/No	No/No	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU	NA	NA	NA
Total OGR Acres			
OGR POG Acres			
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	Yes	Yes
Minimizes roads (total road miles)	2.6	2.6	5.5
Includes streams (Class I stream miles)	2.9	2.9	6.3
Minimizes early seral habitat (acres)	256	256	295
Includes largest remaining block of POG in VCU?	No	No	No
Rare/Underrepresented features (large tree POG acres) [3/]	477	477	755
Deep snow deer/marten habitat (acres) [4/]	488	488	786
Goshawk and murrelet nesting habitat (acres) [5/]	875	875	1,223
Other Considerations			
Maintains Connectivity	Yes	Yes	Yes
Low elevation POG (acres)[6/]	755	755	1,100

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 5900 -North Election Creek

Pre Conveyance: This OGR is directly north of and contiguous with the OGR in 5940. As mapped the small OGR in VCU 5900 is 2,406 acres in size with 1,161 acres of POG (and 571 acres of high volume POG).

The 2002 POW review team modified 1997 TLMP small OGR to increase total acres. This proposal removed high-elevation areas from side slopes of middle fork of Staney Creek and adds low elevation stands along the north fork of Staney Creek, adds high value deer winter range and potential goshawk and murrelet nesting habitat. Addition of POG will aid in maintaining flying squirrel habitat. About 50 percent of POG is in riparian buffer. This OGR provides connectivity through the Staney Creek watershed to the Small OGR in VCU 5940. The 2006 Forest Plan adopted this proposal.

Pre Conveyance: The land conveyance reduced the OGR in this VCU by 83 acres. As a result of the land conveyance the OGR in this VCU does not meet the minimum acres and POG acres requirements for a small OGR in this VCU (see Figure 3).

2015 Rationale/Notes: The 2015 IRT did not evaluate the OGR in this VCU. This OGR will still connected to the remaining OGR in VCU 5940 and so is connected through that OGR and the OGR in VCU 5950 to the Honker OGR. Via e-mails the OGR in this VCU was modified to improve the connectivity between this OGR and the OGR in VCU 5940. As a result of the land conveyance the remaining corridor connecting these two OGRs was less than 1,000 feet wide. With the proposed modification the corridor width now exceeds 1,000 feet in width. The modification results in the addition of about 395 total acres with about 189 of those acres being POG. The modification also added about 60 acres of young growth to the OGR.

Comparison of Small OGR in VCU 5900

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	13,795		
Non-NFS land (acres)	0	168	168
NFS land Total (acres)	13,795	13,627	13,627
16% of NFS land (Min. Req. OGR ac)	2,207	2,180	2,180
All Non-development LUD in VCU	2,406	2,323	2,323
Small OGR (total acres)[1/]	2,406	2,232	2,627
8% of NFS land (Min. POG Req. acres)	1,104	1,090	1,090
OGR POG (total acres)[2/]	1,172	1,098	1,287
All Non-development LUD POG	1,172	1,098	1,287
Acreage requirements met? (Total/POG)	Yes/Yes	Yes/Yes	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU	N/A		
Total OGR Acres			
OGR POG Acres			
Small OGR LUD Overlap from Adjacent VCU			
VCU	N/A		
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	Yes	Yes
Minimizes roads (total road miles)	6.9	6.6	7.2
Includes streams (Class I stream miles)	12.5	11.7	11.7
Minimizes early seral habitat (acres)	435	435	+60
Includes largest remaining block of POG in VCU?	No	No	No
Rare/Underrepresented features (large tree POG ac) [3/]	532	489	519
Deep snow deer/marten habitat (acres) [4/]	592	548	554
Goshawk and murrelet nesting habitat (acres) [5/]	615	571	648
Other Considerations			
Maintains Connectivity	Yes	Yes	Yes
Low elevation POG (acres)[6/]	1,114	1,041	1,041

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCUs 5900, 5940 and 5950

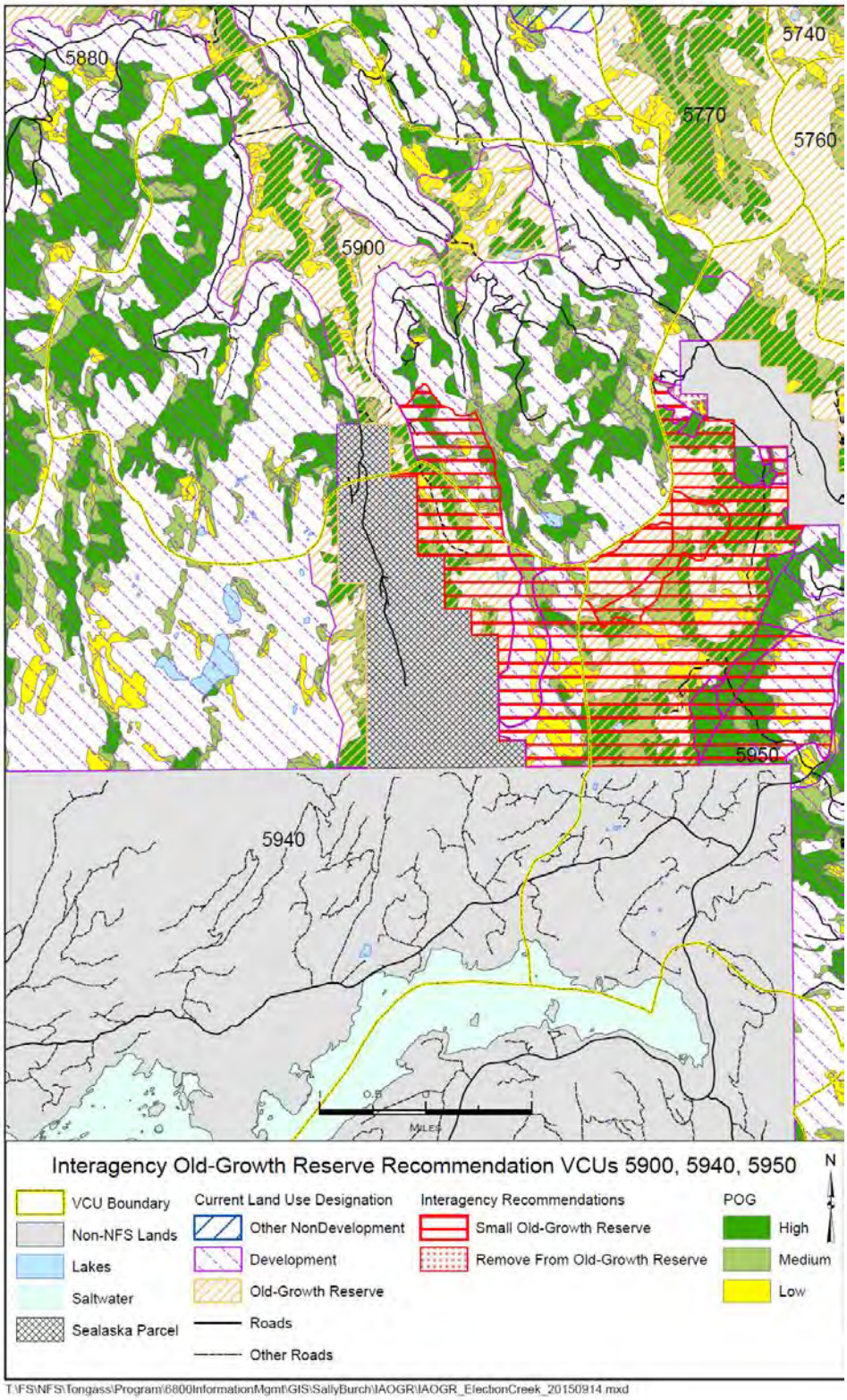


Figure 3

VCU 6850 -Nutkwa

Pre Conveyance: The OGR in this VCU is contiguous with non-development LUDs in VCU compartments of this VCU; VCU 6851 and VCU 6852.

The OGR maintains HPOG, deer winter range, and a low elevation corridor connecting Keeta Inlet to Nutkwa Lagoon.

Post Conveyance: The land conveyed to Sealaska consisted of mostly high volume POG; however even with land conveyance the remaining OGR will still be contiguous with the SPOW wilderness as well as Nutkwa LUD II area. The remaining OGR maintains some low elevation connection between Keeta Inlet and Nutkwa Lagoon.

2015 Rationale/Notes: The 2015 IRT recommends moving the OGR to the south to include the largest remaining contiguous block of POG outside the existing OGR. This modified OGR also includes potential murrelet and goshawk nesting habitat, western facing slopes, and provides an elevational corridor from the alpine to the saltwater (see Figure 4).

Comparison of Small OGR in VCU 6850

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	17,490		
Non-NFS land (acres)	5,248	14,241	14,241
NFS land Total (acres)	12,242	3,249	3,249
16% of NFS land (Min. Req. OGR acres)	1,959	520	520
All Non-development LUD in VCU	2,221	1,001	1,985
Small OGR (total acres)[1/]	2,058	914	984
8% of NFS land (Min. POG Req. acres)	980	260	260
OGR POG (total acres)[2/]	1,458	453	555
All Non-development LUD POG	1,500	484	1,038
Acreage requirements met? (Total/POG)	Yes/Yes	Yes/Yes	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU 6870			
Total OGR Acres	16	16	7
OGR POG Acres	3	3	0
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	No	Yes
Minimizes roads (total road miles)	0.0	0.0	0.0
Includes streams (Class I stream miles)	1.0	0.0	0.0
Minimizes early seral habitat (acres)	0	0	0
Includes largest remaining block of POG in VCU?	No	No	Yes
Rare/Underrepresented features (large tree POG acres) [3/]	468	16	120
Deep snow deer/marten habitat (acres) [4/]	501	11	90
Goshawk and murrelet nesting habitat (acres) [5/]	858	227	342
Other Considerations			
Maintains Connectivity	Yes	No	Yes
Low elevation POG (acres)[6/]	745	16	1,119

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 6850

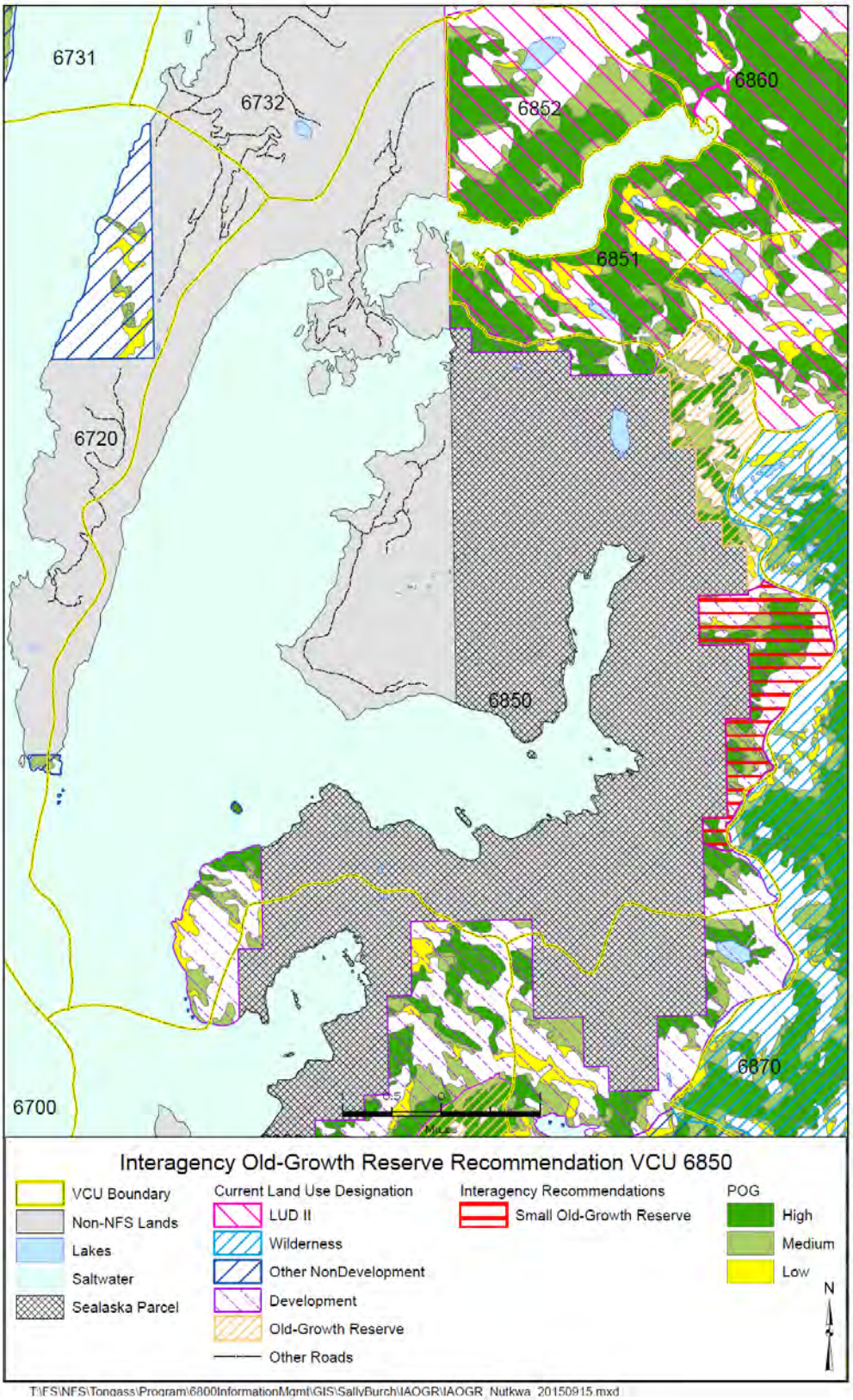


Figure 4

VCU 6200 -Dog Salmon

This small OGR was only minimally impacted by the land conveyance; however most of these acres were high volume POG. The OGR was adjusted to compensate for this loss. The 2015 IRT recommendation includes the addition of a similarly sized piece of high volume POG just to the south of what was conveyed (see Figure 5).

Comparison of Small OGR in VCU 6200

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	24,800		
Non-NFS land (acres)	1,310	4,013	4,013
NFS land Total (acres)	23,490	20,787	20,787
16% of NFS land (Min. Req. OGR acres)	3,758	3,326	3,326
All Non-development LUD in VCU	3,874	3,710	3,943
Small OGR (total acres)[1/]	3,827	3,707	3,940
8% of NFS land (Min. POG Req. acres)	1,879	1,663	1,663
OGR POG (total acres)[2/]	1,907	1,836	1,919
All Non-development LUD POG (acres)	1,918	1,836	1,919
Acreage requirements met? (Total/POG)	Yes/Yes	Yes/Yes	Yes/Yes
Small OGR LUD Overlap into Adjacent VCU			
VCU	NA	NA	NA
Total OGR Acres			
OGR POG Acres			
Small OGR LUD Overlap from Adjacent VCU			
VCU	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	Yes	Yes
Minimizes roads (total road miles)	13.7	13.1	13.1
Includes streams (Class I stream miles)	9.3	8.9	8.9
Minimizes early seral habitat (acres)	716	716	745
Includes largest remaining block of POG in VCU?	No	No	No
Rare/Underrepresented features (large tree POG acres) [3/]	963	912	991
Deep snow deer/marten habitat (acres) [4/]	836	796	796
Goshawk and murrelet nesting habitat (acres) [5/]	1,357	1,306	1,387
Other Considerations			
Maintains Connectivity	Yes	Yes	Yes
Low elevation POG (acres)[6/]	1,217	1,156	1,156

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

VCU 6200

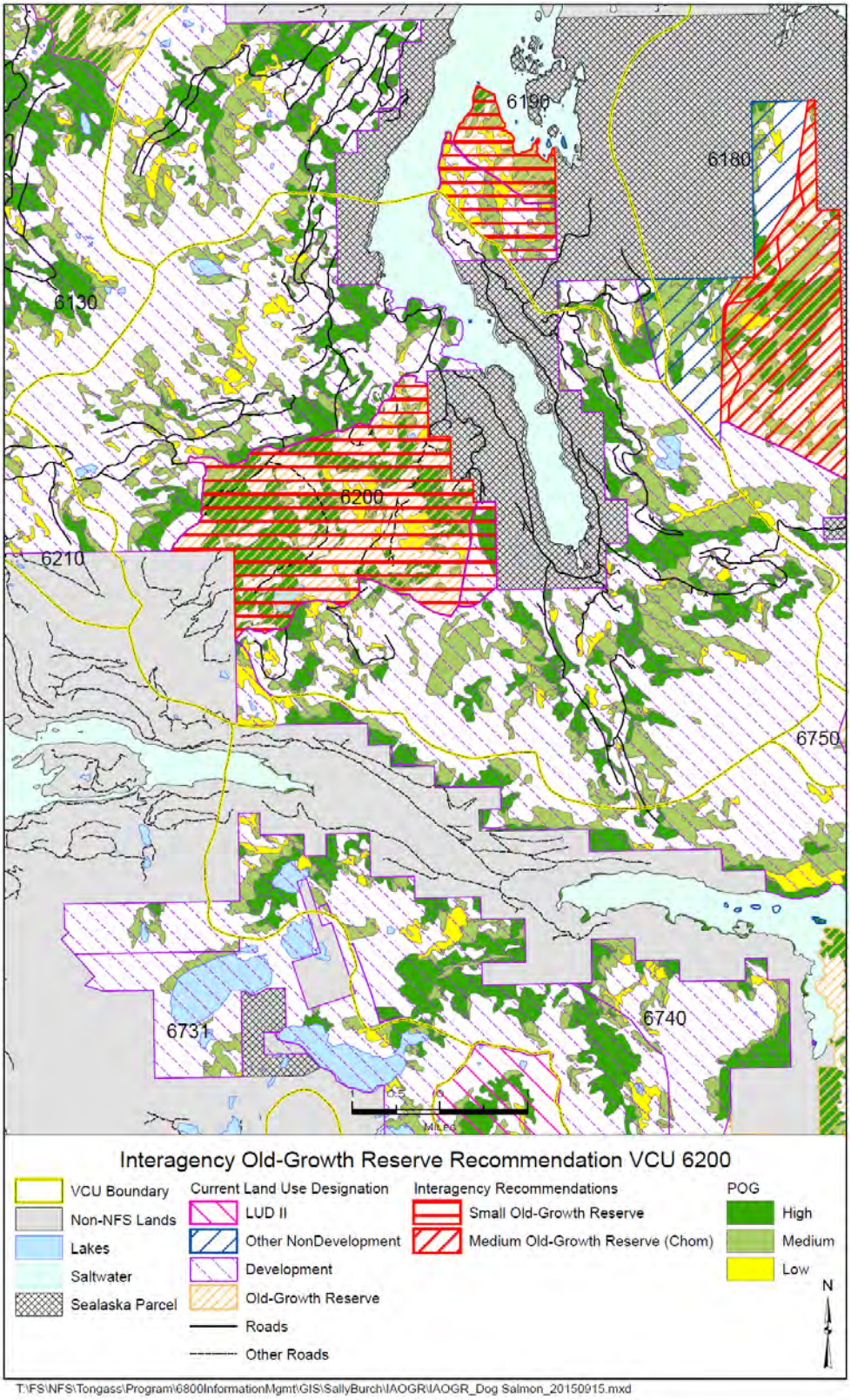


Figure 5

Old Thom's Medium

Pre-Conveyance: The medium OGR in this area consisted of acres designated as OGR in VCUs 6180 and 6190 and the Old Thom's Natural Research Area (RNA) in VCU 6180. Included in the RNA was a USGS Gauging Station. Medium OGRs are supposed to be approximately 10,000 acres in size with a minimum of 5,000 acres of POG and a minimum of 2,500 acres of HPOG, and no farther than 8 miles from other medium or large OGRs, in the four cardinal directions (1997 Forest Plan Appendix K).

Post Conveyance: The Sealaska land conveyance affected the medium OGR in VCUs 6180 and 6190. The resulting acres do not meet the criteria in the 1997 TLMP Appendix K for a medium OGR. The loss of the medium OGR violates the 8 mile proximity requirement for the medium OGRs.

2015 IOGR Rationale/Notes: Options for remedying the loss of the medium in this area include establishing new medium OGR, and/or adjusting/expanding current existing ones to decrease distance between OGRs. The 2015 interagency group considered the intent of the Conservation Strategy at the larger landscape scale for this land area. Lands near Sunny Cove are particularly valuable for wildlife, and could be a small OGR; however, Sunny Cove by itself can't replace or replicate the medium OGR that was lost. Sunny Cove is an intact watershed that may serve as a good replacement for the Old Thom's RNA. The Sunny Cove small OGR in VCU 6750 is near the Cholmondeley medium OGR (VCUs 6170 and 6760) (see Figure 6).

There was discussion as to whether to add the entire Cholmondeley medium to the remaining Old Thom's medium, drop part of the existing Cholmondeley medium, or trade it out entirely (but that option doesn't account for the loss of the Old Thom's medium OGR).

The replacement of the medium in the Old Thom's area needs to be considered at a landscape scale across many VCUs. The proposed replacement of the medium in this area impacts VCUs 6160 (Monie Lake), 6170 (Clover Bay), 6180 (Old Thom's), 6190 (Goose Bay), 6750 (Sunny Creek) and 6760 (Cholmondeley) (see Figure 6).

The discussion involved trying to connect what is left of the Old Thom's medium OGR in VCU 6190 to what was the proposed 2006 interagency medium OGR in VCUs 6160, 6170, 6750 and 6760. The 2006 proposed medium OGR boundary would be modified in VCU 6750. The 2015 IRT proposed enlarging the 2006 OGR in VCU 6750 to include acres to the north to connect to the southern boundary of VCU 6180. The 2015 IRT proposal is to build off the remaining medium OGR acres in VCU 6180 and increase the OGR to the south to connect to the proposed OGR in VCU 6750. A disconnected piece of remaining OGR in VCU 6190 south of Goose Bay would be expanded to include all reaming Forest Service acres in this area. VCU 6190 also includes acres across Polk Inlet. The piece south of Goose Bay was included to help minimize the distance between medium OGRs. It is a small isolated piece of OGR that does include low elevation POG habitat (see Figure 6).

The proposed new medium OGR has a total of 19,060 acres with 8,387 of POG and 4,121 acres of high volume POG. This new OGR is circular and includes only 0.7 miles of road, has 34 miles of Class I streams, only 229 acres of young growth, includes the largest block of POG, 1,184 of large tree POG (SD67), 2,697 acres of deep snow deer and marten habitat and 3,971 acres of

potential goshawk and murrelet nesting habitat. This OGR maintains connectivity and includes 5, 745 acres of low elevation POG.

VCU 6160 -Monie Lake

Pre Conveyance: Prior to the 2008 Forest Plan this VCU included both a medium and a small OGR. The location of the OGR was very controversial. It was recommended to consider this OGR for future review. The 1997 TLMP small OGR is linear along the beach fringe, contains few south facing slopes with POG, little habitat for goshawks or marbled murrelet and does not contain the largest contiguous blocks of POG in the watershed.

The 2002 POW review proposed changing the TLMP small OGR to a medium OGR and relocating the OGR to increase acres of POG and high volume POG and make the OGR more circular. The 2002 proposal includes most of the largest blocks of contiguous POG, potential goshawk and murrelet nesting habitat and important deer winter range. The proposed medium OGR would occur along the shore of VCUs 6160, 6170, 6750 and 6760. The 2002 POW review added entire Monie Lake watershed from Lake to shoreline and includes large blocks of POG in this area. The proposed medium would eliminate the need for a small OGR in VCUs 6160 and 6750.

The 2006 IRT biologically preferred OGR in this VCU changed the designation from a small OGR to a medium OGR. The OGR in this VCU would be combined with the OGRs in VCUs 6170, 6750 and 6760 to form a medium OGR.

Post Conveyance: The OGR in this VCU was not directly impacted by the land conveyance.

2015 IRT: The 2015 IRT proposes that the medium OGR in this VCU be the same as the biologically preferred IOGR proposed for the 2008 Forest Plan (2006 IRT IOGR). The existing small OGR in VCU 6160 is expanded; as a result the small amount of existing medium OGR acreage goes away (see Figure 6).

VCU 6170 -Clover Bay

Pre Conveyance: The 2002 POW IRT relocated the TLMP OGR to increase acres of POG and high volume POG and to make more circular. The proposal included most of the largest blocks of contiguous POG, potential goshawk and murrelet nesting habitat and important deer winter range. The OGR in this VCU would be part of the medium OGR that also includes acres in VCUs 6160, 6170, 6750 and 6760.

The 2006 IRT biologically preferred OGR in this VCU changed the designation from a small OGR to a medium OGR. The OGR in this VCU would be combined with the OGRs in VCUs 6750 and 6760 to form a medium OGR.

Post Conveyance: The OGR in this VCU was not directly impacted by the land conveyance.

2015 IRT: The 2015 IRT proposes that the medium OGR in this VCU be the same as the IOGR as proposed for the 2008 Forest Plan (2006 IRT IOGR) (see Figure 6).

VCU 6180 -Old Thom's Research Natural Area

Pre Conveyance: The 2006 IRT modified the 1997 TLMP medium Old Thom Medium OGR by adding acres to south to increase both POG and high volume POG. The medium OGR maintains connectivity in area heavily fragmented by harvest and private lands.

Post Conveyance: Most of what was medium OGR/RNA in this VCU was lost due to the land conveyance.

2015 Review: The 2015 IRT recommends including both the remaining OGR acres and the remaining RNA acres in the proposed medium. The southern boundary of this proposed modified medium OGR will be a Sealaska ROW. This ROW interrupts the connectivity of the medium OGR with other proposed OGR acres in this VCU. The interagency group felt that this ROW was narrow enough as to not pose a significant problem for most species. The 2015 IRT proposed additional acres south of the ROW provide connectivity to OGR acres in VCU 6750 (Sunny Cove). These acres also include low elevation habitat around the south end of McKenzie Inlet (see Figure 6).

VCU 6190 -Goose Bay

Pre Conveyance: According to 2002 POW IRT the medium IOGR exceeded the minimum acre criteria for POG and high POG and it was mentioned to consider reducing OGR size to allow for future management activities.

The 2006 review team recommended modifying the 1997 TLMP medium Old Thom's OGR by adding acres to the south. This modification increased both POG and high POG acres. The added area includes both roads and second growth stands.

The consensus of the 2006 review team was to not adopt the IOGR so as to maintain future harvest opportunities because while the IOGR is preferred biologically reverting to the 1997 TLMP OGR still maintains the integrity of the OGR.

Post Conveyance: Most of what was medium OGR/RNA in this VCU was lost due to the land conveyance.

2015 Review: The 2015 IRT recommends the creation of a new small OGR in this VCU. Alternatives for a small include the Goose Bay area which is currently mapped as part of the medium that was lost. The Goose Bay area is relatively intact, with the last portion of low-elevation POG in this VCU remaining on Forest Service land.

VCU 6750 -Sunny Cove

Pre Conveyance: Prior to the 1997 TLMP, the entire Sunny Cove areas was proposed as a Habitat Conservation Area (HCA). The 1997 TLMP excluded most of the south facing slopes on the north side of Sunny Creek. The 1997 TLMP OGR includes high elevation, low volume isolated patches of narrow strips of timber.

In the 1997 TLMP this VCU contained a small OGR. The 2006 IRT changed the 1997 TLMP small OGR to a medium OGR and added acres to increase POG. The 2006 IRT proposal included most of the largest blocks of contiguous POG, potential goshawk and murrelet nesting habitat, important deer winter range and added a corridor that connects this OGR to the OGR in VCU 6170. The medium OGR would occur along the shore of VCUs 6160, 6170, 6750 and 6760. This proposal dropped the 1997 TLMP small OGR in VCU 6750 and added an area north of Sunny Cove and along Sunny Creek to connect to OGR in VCU 6760. This medium OGR would include acres in VCUs 6160, 6170, 6750 and 6760. This proposal did not include changes to the OGR in VCU 6760 but did included changes to the OGR in VCU 6160 and VCU 6170.

The proposed OGR includes HPOG and low elevation on both sides of Sunny Creek and higher elevation on south side of Sunny Creek. It also includes the large blocks of POG in this area. This option would eliminate the need for a small OGR in VCU 6750. The Polk Timber Sale EIS confirmed the value of wildlife habitat in this only unharvested drainage and avoided harvest in this area. This proposal does not include high value deer winter range north of Sunny Creek or goshawk use areas identified during field work for the timber sale (prey remains).

The 2006 IRT recommended a review of this OGR especially if the Cholmondeley Timber Sale is not completed.

The 2006 IRT changed the small OGR in this VCU (6750) to a medium OGR. Past review document assumed OGR acres in VCU 6160 (Monie Lake) was part of the medium OGR. The location of the medium was very controversial.

The 2006 Interagency Team preferred location was not implemented because there is a proposal for a timber sale with a supplemental ROD in this area. If the timber sale does not occur, then consider implementing the interagency OGR. Management recommended adoption of the Cholmondeley Timber Sale NEPA decision and Forest Plan Amendment OGR.

In the 2006 review the Forest Supervisor decided on the 1997 TLMP OGR. It was also recommended that potential future LTF/MAF sites be maintained in VCUs 6150 or 6160.

Post Conveyance: The OGR in this VCU was not directly impacted by the land conveyance.

2015 Review: The 2015 IRT proposes that the medium OGR in this VCU be reverted back to the IOGR for the 2008 Forest Plan (2006 IRT IOGR). The 2015 IRT proposed moving the current small OGR from the west side of Sunny Creek to the east side and changing the designation from a small OGR to being included as part of the proposed medium (see Figure 6). This proposal includes most of the largest blocks of contiguous POG, potential goshawk and murrelet nesting habitat, important deer winter range and adds a corridor that connects this OGR to the OGR in VCU 6170. The value of this area as an unharvest watershed has been recognized since the Polk Timber Sale EIS (1995).

VCU 6760 -Cholmondeley

Pre Conveyance: The 2006 IRT proposed modifying the 1997 TLMP medium OGR by adding acres to the west to connect to Sunny Point and proposed OGR in VCU 6750. This proposal includes most of the largest blocks of contiguous POG, potential goshawk (prey remains were found) and murrelet nesting habitat and important deer winter range.

Post Conveyance: The OGR in this VCU was not directly impacted by the land conveyance.

2015 IRT: The 2015 IRT proposes that the medium OGR in this VCU be reverted back to the IOGR for the 2008 Forest Plan (2006 IRT IOGR) (Figure 6).

Medium OGR VCUS 6160, 6170, 6180, 6190, 6200, 6750 and 6760

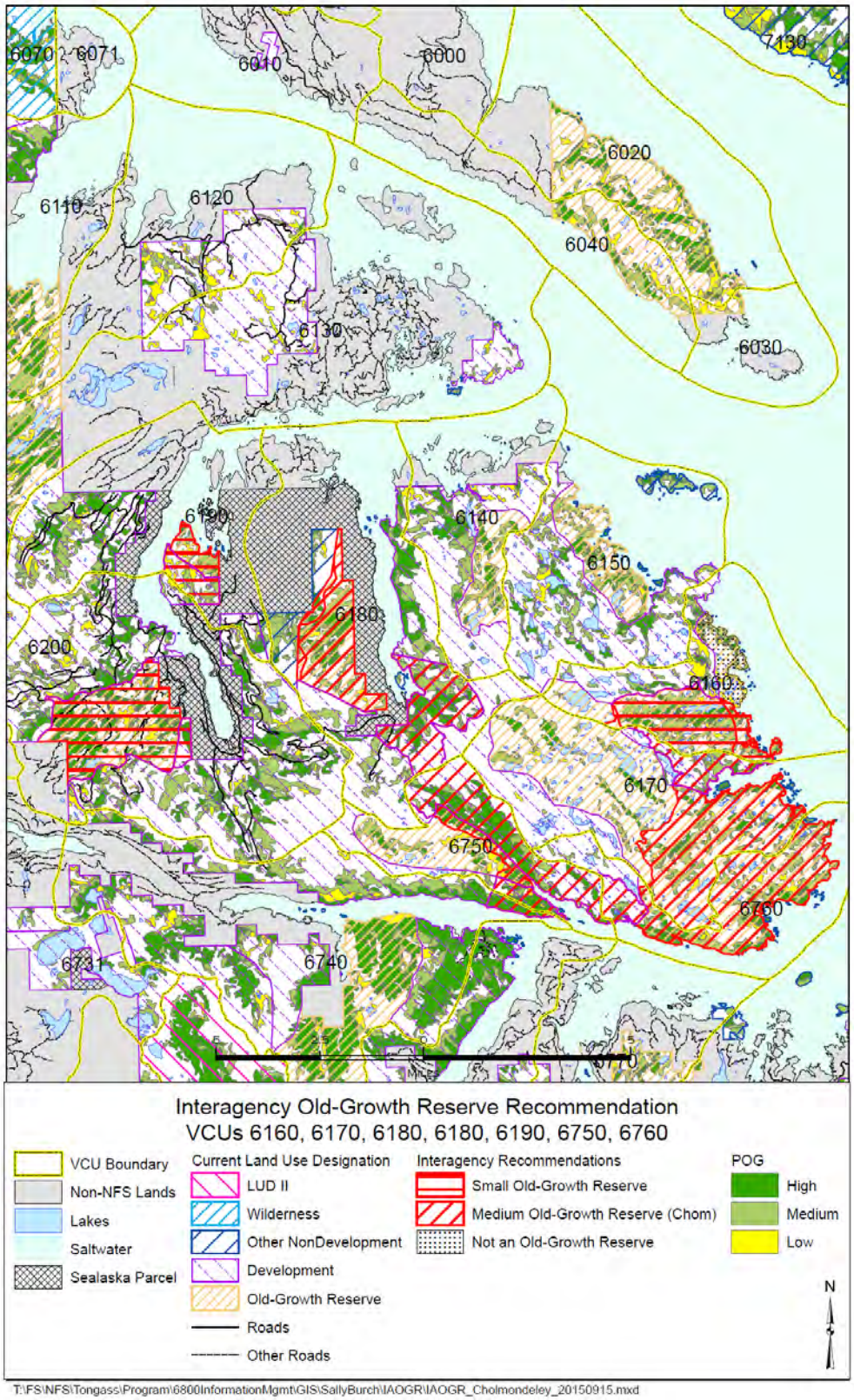


Figure 6

Comparison of Medium OGRs in VCUs 6160, 6170, 6180, 6190, 6750, and 6760 (Monie Lake and Old Thom Medium OGRs)

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land ownership All VCUs (acres)	63,348		
Non-NFS land (acres)	4,651	12,842	12,842
NFS land Total (acres)	58,697	50,801	50,801
Min. Req. OGR acres	10,000		
Min. Req. POG acres	5,000		
Min. Req. High-Volume POG acres	2,500		
Old Thom Medium OGR (VCUs 6180/6190)			
Total Medium OGR Acres	10,238	4,159	See Below
Total Medium OGR POG Acres	7,184	2,030	
Total Medium OGR High-Volume POG Acres	4,293	652	
Acreage requirements met? (Total/POG/HPOG)	Yes/Yes/Yes	No/No/No	
Monie Lake Medium OGR (VCUs 6160, 6170, 6760)			
Total Medium OGR Acres	15,527	15,527	See below
Total Medium OGR POG Acres	4,223	4,223	
Total Medium OGR High-Volume POG Acres	1,429	1,429	
Acreage requirements met? (Total/POG/HPOG)	Yes/No/No	Yes/No/No	
New Cholmondeley Medium OGR (VCUs 6170, 6180, 6750, and 6760)			
Total Medium OGR Acres	See Above	See Above	19,060
Total Medium OGR POG Acres			8,387
Total Medium OGR High-Volume POG Acres			4,121
Acreage requirements met? (Total/POG/HPOG)			Yes/Yes/Yes
Contributing VCUS			
VCU 6160			
Total land ownership (acres)	6,207		
Non-NFS land (acres)	0	0	0
NFS Land (acres)	6,207	6,207	6,207
Total Medium OGR (acres)	691	691	0
All Non-development LUD in VCU (acres)	1,954	1,954	4,091
Medium OGR POG (acres)[2/]	16	16	0
Medium OGR High-volume POG (acres)	0	0	0
All Non-development LUD POG in VCU (acres)	620	620	1,822
All Non-development LUD High-volume POG in VCU (ac)	132	132	473
VCU 6170			
Total land ownership (acres)	14,370		
Non-NFS land (acres)	0	0	0
NFS Land (acres)	14,370	14,370	14,370
Total Medium OGR (acres)	10,786	10,786	5,721
All Non-development LUD in VCU (acres)	10,927	10,927	11,876
Medium OGR POG (acres)[2/]	2,321	2,321	1,809
Medium OGR High-volume POG (acres)	827	827	591
All Non-development LUD POG in VCU (acres)	2,443	2,443	2,802
All Non-development LUD High-volume POG in VCU (ac)	942	942	1,016
VCU 6180			
Total land ownership (acres)	18,234		
Non-NFS land (acres)	1,075	6,573	6,573
NFS Land (acres)	17,159	11,661	11,661
Total Medium OGR (acres)	8,730	3,703	4,820
All Non-development LUD in VCU (acres)	8,854	3,755	6,068
Medium OGR POG (acres)[2/]	6,009	1,715	2,408

Comparison of Medium OGRs in VCUs 6160, 6170, 6180, 6190, 6750, and 6760 (Monie Lake and Old Thom Medium OGRs)

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
Medium OGR High-volume POG (acres)	3,655	610	1,186
All Non-development LUD POG in VCU (acres)	6,033	1,739	2,924
All Non-development LUD High-volume POG in VCU (ac)	3,657	612	1,273
VCU 6190			
Total land ownership (acres)	12,071		
Non-NFS land (acres)	3,563	5,962	5,962
NFS Land (acres)	8,508	6,109	6,109
Total Medium OGR (acres)	1,543	492	0
All Non-development LUD in VCU (acres)	1,649	497	1,101
Medium OGR POG (acres)[2/]	1,176	315	0
Medium OGR High-volume POG (acres)	638	41	0
All Non-development LUD POG in VCU (acres)	1,210	320	647
All Non-development LUD High-volume POG in VCU (ac)	655	44	69
VCU 6750			
Total land ownership (acres)	6,887		
Non-NFS land (acres)	11	11	11
NFS Land (acres)	6,876	6,876	6,876
Total Medium OGR (acres)	0	0	3,984
All Non-development LUD in VCU (acres)	2,522	2,522	6,024
Medium OGR POG (acres)[2/]	0	0	2,187
Medium OGR High-volume POG (acres)	0	0	1,673
All Non-development LUD POG in VCU (acres)	968	968	2,774
All Non-development LUD High-volume POG in VCU (ac)	409	409	1,797
VCU 6760			
Total land ownership (acres)	5,579		
Non-NFS land (acres)	0	0	0
NFS Land (acres)	5,579	5,579	5,579
Total Medium OGR (acres)	4,014	4,014	4,534
All Non-development LUD in VCU (acres)	4,067	4,067	4,615
Medium OGR POG (acres)[2/]	1,886	1,886	1,983
Medium OGR High-volume POG (acres)	601	601	671
All Non-development LUD POG in VCU (acres)	1,925	1,925	2,022
All Non-development LUD High-volume POG in VCU (ac)	614	614	682
Appendix D General Design Criteria and Other Considerations			
Old Thom Medium OGR			
Appendix D Design Criteria			See Below
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	Yes	No	
Minimizes roads (total road miles)	0.0	0.0	
Includes streams (Class I stream miles)	10.7	2.9	
Minimizes early seral habitat (acres)	9	9	
Includes largest remaining block of POG in VCU?	Yes	No	
Rare/Underrepresented features (large tree POG acres) [3/]	3,229	456	
Deep snow deer/marten habitat (acres) [4/]	2,982	123	
Goshawk and murrelet nesting habitat (acres) [5/]	4,293	652	
Other Considerations			
Maintains Connectivity	Yes	No	
Low elevation POG (acres)[6/]	4,218	473	
Monie Lake Medium OGR			
Appendix D Design Criteria			See Below

Comparison of Medium OGRs in VCUs 6160, 6170, 6180, 6190, 6750, and 6760 (Monie Lake and Old Thom Medium OGRs)

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	No	No	
Minimizes roads (total road miles)	0.0	0.0	
Includes streams (Class I stream miles)	24.6	24.6	
Minimizes early seral habitat (acres)	0	0	
Includes largest remaining block of POG in VCU?	No	No	
Rare/Underrepresented features (large tree POG acres) 3/	378	378	
Deep snow deer/marten habitat (acres) 4/	1,196	1,196	
Goshawk and murrelet nesting habitat (acres) 5/	1,429	1,429	
Other Considerations			
Maintains Connectivity	Yes	Yes	
Low elevation POG (acres)6/	3,417	3,417	
Proposed New Cholmondeley Medium OGR			
Appendix D Design Criteria	See Above	See Above	
Circular rather than linear to maximize interior habitat/minimize fragmentation effects			Yes
Minimizes roads (total road miles)			0.7
Includes streams (Class I stream miles)			34.0
Minimizes early seral habitat (acres)			229
Includes largest remaining block of POG in VCU?			Yes
Rare/Underrepresented features (large tree POG acres) 3/			1,884
Deep snow deer/marten habitat (acres) 4/			2,697
Goshawk and murrelet nesting habitat (acres) 5/			3,971
Other Considerations			
Maintains Connectivity			Yes
Low elevation POG (acres)6/			5,745

1/Medium OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should also include 2,500 acres of high-elevation POG
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

Comparison of Small OGR in VCU 6160

	Pre-conveyance	Post-conveyance	2015 Biologically Preferred
General VCU Info./Forest Plan Appendix K Criteria			
Total land all ownership (acres)	6,207		
Non-NFS land (acres)	0		0
NFS land Total (acres)	6,207		6,207
16% of NFS land (Min. Req. OGR acres)	992		992
All Non-development LUD in VCU (acres)	1,954		4,091
Small OGR (acres)[1/]	1,247		2,558
8% of NFS land (Min. POG Req. acres)	496		496
OGR POG (acres)[2/]	597		1,441
All Non-development LUD POG in VCU (acres)	620		2,460
Acreage requirements met? (Total/POG)	Yes/Yes		Yes/Yes
Small OG LUD Overlap into Adjacent VCU			
VCU #	NA	NA	NA
Total OGR Acres			
OGR POG Acres			
Small OG LUD Overlap from Adjacent VCU			
VCU #	NA	NA	NA
Total Acres			
POG Acres			
Appendix D General Design Criteria			
Circular rather than linear to maximize interior habitat/minimize fragmentation effects	No		Yes
Minimizes roads (total road miles)	0.0		0.0
Includes streams (Class I stream miles)	5.2		8.0
Minimizes early seral habitat (acres)	0		0
Includes largest remaining block of POG in VCU?	No		Yes
Rare/Underrepresented features (large tree POG acres) [3/]	38		270
Deep snow deer/marten habitat (acres) [4/]	132		325
Goshawk and murrelet nesting habitat (acres) [5/]	132		379
Other Considerations			
Maintains Connectivity	Yes		Yes
Low elevation POG (acres)[6/]	597		1,255

1/Small OGR includes all OG and other Non-Dev LUDs that apply to the VCU to meet Forest Plan Standard and Guidelines for this reserve. This includes overlap into adjacent VCUs and excludes Non-Dev LUD in the VCU not associated with this reserve.
2/ Should be approximately 50% of OGR acres
3/ SD67 type
4/ High-volume POG ≤ 800 feet in elevation
5/ High-volume POG all elevations (indicative of optimal goshawk and marbled murrelet nesting habitat due to presence of large trees and snags, though both species may use all POG types)
6/ All POG ≤ 800 feet in elevation (representative of low-elevation travel corridors important for many species)

Interagency Old Growth Reserve Review
Sealaska Land Conveyance

September 2015

9/11/15

Maria Dillman USDA Forest Service Wildlife Biologist

9/15/2015

Steve Brockmann, USFWS Wildlife Biologist

9/15/15

Steve Bethune, ADF&G Wildlife Biologist

9/15/15

Mark Minnillo, ADF&G Wildlife Biologist

APPENDIX F
COMPARISON OF DIRECTION BY ALTERNATIVE

Appendix F

Comparison of Direction by Alternative

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TABLES

Table F-1. Comparison of Young-Growth Direction by Alternative F-5

Appendix F
Comparison of Direction by Alternative

Introduction

Chapter 5 of the Forest Plan contains the proposed direction for Alternative 5 (the Preferred Alternative). Direction in Chapter 5 applies to the entire plan area (forest-wide) or to specific LUDs as explained in Chapter 3. Management direction includes plan components and management approaches. This appendix shows how direction for the other alternatives compares to Alternative 5, whether direction is identical, or how it differs. This appendix follows the organization of Chapter 5 and presents the comparison in this order: Young Growth, Renewable Energy, Transportation System Corridors, and Forest-wide direction.

Young-Growth Direction

Table F-1, located at the end of this appendix, displays the proposed young-growth direction for Alternative 5 (the Preferred Alternative), which is the basis for the Forest Plan (see Forest Plan Chapter 5). The table also shows how direction for the other alternatives compares to Alternative 5, whether direction is identical, or how it differs.

Management approaches for young growth for Alternative 5 are presented in the Forest Plan Chapter 5 and are not repeated here. The following sections present how Alternatives 2 through 5 Management Approaches compare to those of Alternative 5. No management approaches would apply to Alternative 1, the No Action Alternative.

Management Approaches for Young Growth

Alternative 5:

See Forest Plan Chapter 5.

Alternative 2-4:

The intent is that responsible officials engage stakeholders (for example, conservation interests, timber operators, permitted user groups, and other interested parties) early and often to best design projects that meet ecological, social, and economic interests. Such inclusion would surface and resolve differences, and minimize and avoid social, environmental, and natural resource conflicts. At the earliest possible time, Interdisciplinary Teams (IDTs) would engage scientific and technical expertise, and knowledge of local resources to encourage creative thinking and enhance integration and coordination among jurisdictions.

The intent is that during project planning, IDTs identify other resource opportunities in the project area, and integrate these opportunities into the project design. (See definition for Integrated Resource Management in Chapter 7.) When designing young-growth projects that would advance old-growth characteristics in the beach fringe, riparian management area (RMA), or old-growth reserve (OGR), IDTs seek out stakeholders to encourage creative and innovative approaches for developing silvicultural treatments that imitate the natural scale and distribution of disturbance patterns on the Tongass (e.g., wind-thrown timber that creates gaps and patches; landslides that create corridors and gaps; mortality that naturally thins stand). The intent is that treatments in RMAs would address stream process group objectives. (Consult Appendix D, and Exhibit 2 in the Tongass Young Growth Management Strategy [USDA Forest Service 2014d].)

Where appropriate, line officers would use Stewardship Authority (FSH 2409.19, Chapter 60) and other authorities to help achieve land management goals while meeting regional and local community needs.

Management Approaches for Beach and Estuary Fringe

Alternative 5:

See Forest Plan Chapter 5.

Alternative 2:

The intent is that the IDT assesses the highly productive, sensitive, and valuable fish and wildlife habitat found in estuaries to determine how to protect these important resources. Forest Plan Appendix D provides guidance for delineating RMAs associated with estuarine stream process group.

The intent is that the IDT consult and integrate permit holders, local users, and user groups in planning in the development of any management activity.

When even-aged management of young growth occurs in the beach and estuary fringe, the intent is to maintain an approximate 1,000-foot-wide protected corridor adjacent and inland of the harvest unit to function as an alternate, low elevation, natural habitat corridor.

Alternative 3:

Same as Alternative 5.

Alternative 4:

Same as Alternative 5 with the addition of:

To maintain or improve habitat conditions and long-term ecological function, it is expected that the IDT would minimize the size of created openings in stands previously treated for wildlife and fish habitat purposes.

Management Approach for Karst and Cave Resources

Alternatives 2-4:

Same as Alternative 5.

Management Approaches for Recreation and Tourism

Alternatives 2-4:

Same as Alternative 5.

Management Approaches for Riparian

Alternative 2:

Same as Alternative 5.

Alternative 3:

No management approaches.

Alternative 4:

To maintain or improve habitat conditions and long-term ecological function, it is expected that the IDT would minimize the size of created openings in stands previously treated for wildlife and fish habitat purposes.

Management Approaches for Scenery

Alternatives 2-4:

No management approaches.

Management Approaches for Soil and Water

Alternatives 2-4:

Same as Alternative 5.

Management Approaches for Timber

Alternatives 2-4:

Same as Alternative 5.

Management Approaches for Wildlife

Alternative 2:

It is expected that project IDT and the interagency review team of USDA Forest Service, U.S. Fish and Wildlife Service, and Alaska Department of Fish and Game biologists would jointly work to identify young growth for harvest within the Old-growth Habitat LUD that can be exchanged for old growth from adjacent landscapes, where a net gain of productive old growth habitat in the Old-growth Habitat LUD is possible while maintaining and enhancing landscape connectivity. (See Appendix K.)

Alternative 3:

It is expected that project IDT and the interagency review team of USDA Forest Service, U.S. Fish and Wildlife Service, and Alaska Department of Fish and Game biologists would jointly work to identify young growth for harvest within the Old-growth Habitat LUD that can be exchanged for old growth from adjacent landscapes, where a net gain of productive old growth habitat in the Old-growth Habitat LUD is possible while maintaining and enhancing landscape connectivity. (See Appendix K.)

When implementing young-growth timber harvest projects larger than 20 acres in VCUs that have had concentrated past timber harvest, it is intended that 30 percent of the young growth stand acres should be left. The purpose is to retain sufficient residual trees to diversify the structural characteristics of the stand and provide for future recruitment of snags. The VCUs where this is intended to apply are ones in

which 33 percent or more of the productive old growth has been harvested since 1954. (Consult Forest Plan Chapter 4 under Wildlife section (WILD1), IV. Legacy Forest Structure

Alternative 4:

When implementing young-growth timber harvest projects larger than 20 acres in VCUs that have had concentrated past timber harvest, it is intended that 30 percent of the young growth stand acres should be left. The purpose is to retain sufficient residual trees to diversify the structural characteristics of the stand and provide for future recruitment of snags. The VCUs where this is intended to apply are ones in which 33 percent or more of the productive old growth has been harvested since 1954. (Consult Forest Plan Chapter 4 under Wildlife section (WILD1), IV. Legacy Forest Structure.)

To maintain or improve habitat conditions and long-term ecological function, it is expected that the IDT would minimize the size of created openings in stands previously treated for wildlife and fish habitat purposes.

Renewable Energy Direction

All plan content for Renewable Energy presented in proposed Plan Chapter 5 apply to Alternatives 3 and 4. They do not apply to Alternative 1, No Action. For Alternative 2, the plan components are identical to the preferred alternative except S-RE-SCENE-01. Under Alternative 2, the following standard would be applied:

> S-RE-SCENE-01: Apply the Low Scenic Integrity Objective (SIO) to renewable energy sites. (Consult Forest Plan Chapter 4, Scenery Preparation: SCENE2 section.)

Management Approach for Renewable Energy

The management approaches for Renewable Energy presented in Chapter 5 apply to all action alternatives. (They do not apply to Alternative 1, No Action.)

Transportation System Corridors Direction

All plan components for Transportation System Corridors presented in Chapter 5 apply to all action alternatives. (They do not apply to Alternative 1, No Action.)

Management Approach for Transportation System Corridors

The management approaches for Transportation System Corridors presented in Chapter 5 apply to all action alternatives. (They do not apply to Alternative 1, No Action.)

Forest-Wide Direction

Chapter 5 of the Forest Plan includes Forest-wide plan Desired Conditions (Chapter 2), Multiple-use Goals and Objectives (Chapter 2), Standards and Guidelines (Chapter 4). The proposed direction presented for Alternative 5 (the Preferred Alternative) applies to all Action Alternatives.

Table F-1 displays the proposed Young-Growth direction for Alternative 5 (the Preferred Alternative), for which the Forest Plan has been prepared (see Chapter 5). This table also shows how direction for the other alternatives compares to Alternative 5, whether direction is identical, or how it differs. The LUDs that a particular plan component would apply to are indicated using the following abbreviations: Old-growth habitat (OGH); Remote Recreation (RM); Recreation River (RR); Special Interest Area (SA); Semi-Remote Recreation (SM); Scenic River (SR); Scenic Viewshed (SV); Modified Landscape (ML); Timber Production (TM)

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Young Growth (YG)				
Desired Condition (DC)				
DC-YG-01: Young-growth forests produce desired resource values, products, services and conditions in ways that sustain the diversity and productivity of ecosystems. Lands suitable for timber production produce sawtimber and other wood products on an even-flow, long-term sustained yield basis; the timber yield contributes to the projected timber sale quantity (PTSQ).Timber and other ecosystem services from young-growth forest resources provide economical and sustainable opportunities that support Southeast Alaska communities. [OGH, SV, ML, TM]	Desired Conditions for young-growth timber are found in Chapter 4 of the approved 2008 Forest Plan under Timber and in the Tongass Young Growth Management Strategy Exhibit 1-Timber Approach (2014).	DC-YG-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-01 is identical to Alternative 5. [SV, ML and TM LUDs only]
DC-YG-02: Pre-commercial thinning treatment of young-growth timber stands approaching, or at, the stem-exclusion stage, increase stand growth and vigor (e.g., larger trees, small canopy gaps, diverse understory).Treatments occur where highest productivity, harvest operability and access is favorable. [OGH, SV, ML, TM]		DC-YG-02 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-02 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-02 is identical to Alternative 5. [SV, ML and TM LUDs only]
DC-YG-03: Harvesting of young-growth stands provides opportunities to improve or maintain fish and wildlife habitat by accelerating old-growth characteristics. [OGH]		DC-YG-03 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-03 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-03 is identical to Alternative 5. [SV, ML and TM LUDs only]

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
DC-YG-04: Harvesting of young-growth stands in Riparian Management Areas (RMAs) and Beach Fringe provides opportunities to improve or maintain fish and wildlife habitat by accelerating old-growth characteristics. [OGH, SV, ML, TM]		DC-YG-04 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	**DC-YG-04:** Harvesting of young-growth stands in the Beach Fringe provides opportunities to improve or maintain fish and wildlife habitat by accelerating old-growth characteristics. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-04 is identical to Alternative 3. [SV, ML and TM LUDs only]
DC-YG-05: At the end of the planned rotation for young growth, stands are in a condition whereby regeneration harvests using even-aged, two-aged or uneven-aged silvicultural systems are feasible and appropriate. [SV, ML, TM]		DC-YG-05 is identical to Alternative 5. [RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-05 is identical to Alternative 5. [RM, RR, SA, SM, SR, SV, ML and TM LUDs only	DC-YG-05 is identical to Alternative 5. [SV, ML and TM LUDs only]
Suitability of Lands (SUIT)				
SUIT-YG-01: Lands within Old-growth Habitat, Scenic Viewshed, Modified Landscape, and Timber Production LUDs are suitable for young-growth timber production, unless they do not meet the other suitability requirements (See Appendix A). Timber management within these LUDs is compatible with desired conditions for young-growth management. [OGH, SV, ML, TM]	Suitability of lands for timber production are found in Appendix A of the current 2008 Forest Plan.	**SUIT-YG-01:** Lands within Old-growth Habitat, Remote Recreation, Recreational River, Special Interest Area, Semi-remote Recreation, Scenic River, Scenic Viewshed, Modified Landscape, and Timber Production LUDs are suitable for young-growth timber production if they meet the other suitability requirements in 36 CFR 219.11. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	SUIT-YG-01 is identical to Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	**SUIT-YG-01:** Lands within Scenic Viewshed, Modified Landscape, and Timber Production LUDs are suitable for young-growth timber production if they meet the other suitability requirements in 36 CFR 219.11. [SV, ML and TM LUDs only]
Objectives (O)				
O-YG-01: During the 15 years after plan approval, the amount of young-growth offered would gradually increase to exceed 50 percent of the timber offered annually. [OGH, SV, ML, TM]	Objectives for young-growth timber are found in Chapter 4 of the approved 2008 Forest Plan under Timber and in the Tongass Young	O-YG-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	O-YG-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	O-YG-01 is identical to Alternative 5. [SV, ML and TM LUDs only]

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
O-YG-02: During the 15 years after plan approval, offer increasing annual volumes of economically viable young-growth timber. Old-growth timber harvest would gradually be reduced to an average of 5 million board feet (MMBF) annually, to support local mills and investments in re-tooling, depending on markets and demand. [OGH, SV, ML, TM]	Growth Management Strategy Exhibit 1-Timber Approach (2014).	O-YG-02 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	O-YG-02 is identical to Altern 5. [OGH, RM, RR, SA, SM, S ML and TM LUDs only]	O-YG-02 is identical to Alternative 5. [SV, ML and TM LUDs only]
O-YG-03: Annually, pre-commercially thin 4,000 to 7,000 acres of young-growth stands. [OGH, SV, ML, TM]		O-YG-03 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	O-YG-03 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	O-YG-03 is identical to Alternative 5. [SV, ML and TM LUDs only]
Goals (G)				
GL-YG-01: Provide a stable young-growth timber supply that sustains long-term timber yields while maintaining or improving habitat conditions for wildlife and fish at the landscape level (see Proposed Forest Plan Appendix B). [OGH, SV, ML, TM]	Goals for young-growth timber are found in Chapter 4 of the approved Forest Plan under Timber and the Tongass Young Growth Management Strategy Exhibit 1-Timber Approach (2014).	**GL-YG-01:** Provide a stable young-growth timber supply that sustains long-term timber yields without impairment of the productivity of the land, with consideration being given to ecological, social, and economic factors. See Tongass Young Growth Management Strategy (2014). [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-01 is identical to Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-01 is identical to Alternative 2. [SV, ML and TM LUDs only]
GL-YG-02: Pre-commercially treat stands to reduce or eliminate stem exclusion, to decrease stand rotation time, and provide future silvicultural opportunities. [OGH, SV, ML, TM]		GL-YG-02 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-02 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-02 is identical to Alternative 5. [SV, ML and TM LUDs only]
GL-YG-03: Create opportunities in young-growth management and the use of forest products in a manner that enhances the economic vitality of the region and the resilience of local communities. [OGH, SV, ML, TM]		GL-YG-03 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-03 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-03 is identical to Alternative 5. [SV, ML and TM LUDs only]

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
GL-YG-04: Harvest of young-growth timber supports a variety of mill sizes and operators across the forest, including small and micro sales that support economic opportunities. [OGH, SV, ML, TM]		GL-YG-04 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-04 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-04 is identical to Alternative 5. [SV, ML and TM LUDs only]
GL-YG-05: Make available a variety of potential forest products that support the development of an integrated industry based primarily upon young-growth timber harvest. [OGH, SV, ML, TM]		GL-YG-05 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-05 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GL-YG-05 is identical to Alternative 5. [SV, ML and TM LUDs only]
Standard (S)				
S-YG-01: When harvesting trees prior to the culmination of mean annual increment (CMAI) of growth under the authority granted by Public Law 113–291, Sec. 3002, subsection (e)(4)(A), the limitation of subsection (e)(4)(B) shall be applied. [OGH, SV, ML, TM]	Standards for young-growth timber are found in Chapter 4 of the approved Forest Plan under Timber and the Tongass Young Growth Management Strategy Exhibit 1-Timber Approach (2014).	S-YG-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-01 is identical to Alternative 5. [SV, ML and TM LUDs only]
Beach and Estuary Fringe (BEACH)				
Desired Condition (DC)				
DC-YG-BEACH-01: Active management of young-growth stands within the beach and estuary fringe supports a range of social, economic and ecological needs. These areas provide habitat and connectivity for wildlife and opportunities for accelerating old-growth characteristics while also providing commercial timber byproducts. [OGH, SV, ML, TM]	Desired Condition of the beach and estuary fringe are found in Chapter 4 of the approved 2008 Forest Plan under Beach and Estuary Fringe.	DC-YG-BEACH-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-BEACH-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-BEACH-01 is identical to Alternative 5. [SV, ML and TM LUDs only]

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Objectives (O)				
O-YG-BEACH-01: Offer about 3,500 acres of young-growth in the beach and estuary fringe to provide commercial timber during the 15 years after Plan approval. [OGH, SV, ML, TM]	Objectives of the beach and estuary fringe are found in Chapter 4 of the approved 2008 Forest Plan under the Beach and Estuary Fringe section.	**O-YG-BEACH-01:** Offer about 11,300 acres of young-growth in the beach and estuary fringe to provide commercial timber during the 15 years after Plan approval. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	**O-YG-BEACH-01:** Offer about 8,000 acres of young-growth in the beach and estuary fringe to provide commercial timber during the 15 years after Plan approval. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	**O-YG-BEACH-01:** Offer about 5,500 acres of young-growth in the beach and estuary fringe to provide commercial timber during the 15 years after Plan approval. [SV, ML and TM LUDs only]
Suitability of Lands (SUIT)				
SUIT-YG-BEACH-01: Young growth stands within the beach and estuary fringe are suitable for timber production; timber management within these stands is compatible with desired condition DC-YG-BEACH-01. See SUIT-YG- 01 and Appendix A. [OGH, SV, ML, TM]	Lands within the beach and estuary fringe are not suitable for timber production. See DEIS Chapter 2 for Alternative 1 Suitability.	SUIT-YG-BEACH-01 is identical to Alternative 5. See SUIT-YG -01 and DEIS Chapter 2 for Alternative 2 Suitability. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	SUIT-YG-BEACH-01 is identical to Alternative 5. See SUIT-YG- 01 and DEIS Chapter 2 for Alternative 3 Suitability. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	SUIT-YG-BEACH-01 is identical to Alternative 5. See SUIT-YG- 01 and DEIS Chapter 2 for Alternative 4 Suitability. [SV, ML and TM LUDs only]
Standards (S)				
S-YG-BEACH-01: The maximum size of any created opening for commercial timber harvest in the beach fringe must not exceed 10 acres and a maximum removal of up to 35 percent of the acres of the original harvested stand is allowed. Commercial thinning is limited to 35 percent of the stand's basal area. A combination of the two treatments may be used, with no more than 35 percent of the total stand removed in either basal area and/or acres. TTRA and other administratively withdrawn areas do not count towards the stand's total acreage. [OGH, SV, ML, TM]	Standards and Guidelines for the beach and estuary fringe are found in Chapter 4 of the approved 2008 Forest Plan under the Beach and Estuary Fringe section.	**S-YG-BEACH-01:** Even aged management is not allowed in young-growth stands within the beach and estuary fringe after 15 years from plan approval. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-BEACH-01: Even-aged management of young-growth timber is not allowed for commercial timber harvest purposes. Commercial Thinning is allowed. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-BEACH-01 is identical to Alternative 3. [SV, ML and TM LUDs only]

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
S-YG-BEACH-02: Harvest of commercial timber within young-growth stands is limited to a one-time only entry and to the first 15 years unless best available scientific information shows that additional entries are: a) warranted, and b) meet the LUD objectives. [OGH, SV, ML, TM]		S-YG-BEACH-02 does not apply. See S-YG-BEACH-01 above.	S-YG-BEACH-02 does not apply.	S-YG-BEACH-02 does not apply.
S-YG-BEACH-03: Commercial harvest within beach fringe and estuary is not allowed within a minimum 200-foot forested buffer beginning at mean high tide (that is, a no commercial harvest buffer). This does not preclude wildlife enhancement projects and providing access to timber harvest units as long as process group objectives can be met in the RMA. [OGH, SV, ML, TM]		S-YG-BEACH-03 does not apply.	S-YG-BEACH-03 does not apply.	S-YG-BEACH-03 does not apply.
Facilities (FAC)				
Standard (S)				
S-YG-FAC-01: Authorize only those facilities (recreation and administrative) that are compatible with young-growth objectives O-YG-01 and O-YG-02. [OGH, SV, ML, TM]	Standards and Guidelines for facilities are found in Chapter 4 of approved 2008 Forest Plan.	S-YG-FAC-01 is identical to Alternative 5	S-YG-FAC-01 is identical to Alternative 5	S-YG-FAC-01 is identical to Alternative 5
Karst and Cave Resources (KC)				
Desired Condition (DC)				
DC-YG-KC-01: The karst and cave ecosystems (or landscapes) maintain natural processes and the productivity, while providing for other land uses. [OGH, SV, ML, TM]	Desired Conditions for Karst and Cave Resources are found in Chapter 4, Karst and Cave Resources, and Appendix H of the approved 2008 Forest Plan.	DC-YG-KC-01 is identical to Alternative 5	DC-YG-KC-01 is identical to Alternative 5	DC-YG-KC-01 is identical to Alternative 5

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Standard (S)				
S-YG-KC-01: Commercial timber harvest is not allowed on lands identified as high vulnerability karst lands. (Consult Appendix H.) [OGH, SV, ML, TM]	Standards and Guidelines for Karst and Cave Resources are found in Chapter 4, Karst and Cave Resources, and Appendix H of the approved 2008 Forest Plan.	S-YG-KC-01: Commercial thinning on high vulnerability karst is allowed on a case-by-case basis. (See young-growth management on karst in Appendix H) [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-KC-01 is identical to Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-KC-01 is identical to Alternative 2. [SV, ML and TM LUDs only]
S-YG-KC-02: On lands identified as medium vulnerability karst (see Appendix H), patch clearcuts are allowed but may not exceed 10 acres with a maximum removal of 35 percent of the acres of the original harvested stand. [OGH, SV, ML, TM]		S-YG-KC-02: Even-age management is allowed on moderate vulnerability karst when karst management objectives (Appendix H) can be met. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-KC-021 is identical to Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-KC-02 is identical to Alternative 2. [SV, ML and TM LUDs only]
S-YG-KC-03: Even-aged management is allowed on lands identified as low vulnerability karst lands. (Consult Appendix H.) [OGH, SV, ML, TM]		S-YG-KC-03: Even-age management is allowed on low vulnerability karst when karst management objectives (Appendix H) can be met. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-KC-03 is identical to Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-KC-03 is identical to Alternative 2. [SV, ML and TM LUDs only]
Lands (LAND)				
Standard (S)				
S-YG-LAND-01: Authorize only those uses that are compatible with young-growth objectives O-YG-01 and O-YG-02. [OGH, SV, ML, TM]	Standards and Guidelines for Lands are found in Chapter 4 of the approved 2008 Forest Plan.	S-YG-LAND-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-LAND-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-LAND-01 is identical to Alternative 5. [SV, ML and TM LUDs only]
Recreation and Tourism (REC)				
Standard (S)				
S-YG-REC-01: Authorize only those uses that are compatible with young-growth objectives O-YG-01 and O-YG-02. [OGH, SV, ML, TM]	Standards and Guidelines for Recreation and Tourism are found in Chapter 4 of the approved 2008 Forest Plan.	S-YG-REC-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-REC-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-REC-01 is identical to Alternative 5. [SV, ML and TM LUDs only]

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Riparian (RIP)				
Desired Condition				
DC-YG-RIP-01: Active management of young-growth stands that are suitable for timber production within riparian management areas (RMAs) supports a range of social, economic and ecological needs. These areas are managed to accelerate old-growth characteristics in order to improve riparian functions for soil, water, fish, wildlife and other resources (see Appendix D), while also providing a commercial timber byproduct. [OGH, SV, ML, TM]	Desired Conditions for riparian management areas are found in Chapter 4, Riparian, and Appendix D of the approved 2008 Forest Plan	DC-YG-RIP-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-RIP-01 is identical to Alternative 1.	DC-YG-RIP-01 is identical to Alternative 1.
Suitability of Lands (SUIT)				
SUIT-YG-RIP-01: Young-growth stands within RMAs (excluding Tongass Timber Reform Act buffers) are suitable for timber production; timber management within these stands is compatible with desired condition DC-YG-RIP-01. See SUIT-YG-01 and Appendix A for Alternative 5. [OGH, SV, ML, TM]	Lands within Riparian Management Areas are not suitable for timber production. See DEIS Chapter 2 for Alternative 1.	SUIT-YG-RIP-01 is identical to Alternative 5. See SUIT-YG-TIM-01 and DEIS Chapter 2 for Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	Lands within Riparian Management Areas are not suitable for timber production. See DEIS Chapter 2 for Alternative 3.	Lands within Riparian Management Areas are not suitable for timber production. See DEIS Chapter 2 for Alternative 4.
Objectives (O)				
O-YG-RIP-01: During the 15 years after plan approval, treat about 900 acres of young-growth in RMAs to provide a commercial timber byproduct. [OGH, SV, ML, TM]	Objectives for riparian management areas are found in Chapter 4 of the approved Forest Plan under Riparian (RIP2).	**O-YG-RIP-01:** During the 15 years after plan approval, treat about 1,600 acres of young-growth in RMAs to provide a commercial timber byproduct. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	Identical to Alternative 1.	Identical to Alternative 1.

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Standards (S)				
S-YG-RIP-01: The maximum size of any created opening for commercial timber harvest in the RMA must not exceed 10 acres and a maximum removal of up to 35 percent of the acres of the original harvested stand is allowed. Commercial thinning is limited to 35 percent of the stand's basal area. A combination of the two treatments may be used, with no more than 35 percent of the total stand removed in either basal area and/or acres. TTRA and other administratively withdrawn areas do not count toward the stand's total acreage. [OGH, SV, ML, TM]	Standards and Guidelines for riparian management areas are found in Chapter 4 of the approved 2008 Forest Plan under the Riparian section.	**S-YG-RIP-01:** Even-aged management is not allowed in RMAs. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	Identical to Alternative 1.	Identical to Alternative 1.
S-YG-RIP-02: Harvest of commercial timber within young-growth stands is limited to a one-time only entry and to the first 15 years unless best available scientific information shows that additional entries are: a) warranted, and b) meet the LUD objectives. [OGH, SV, ML, TM]		**S-YG-RIP-02:** Commercial thinning is allowed in RMAs with a maximum removal of 33 percent of the stand. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]		
Scenery (SCENE)				
Standards (S)				
S-YG-SCENE-01: Apply the Very Low Scenery Integrity Objectives (SIO) for young-growth harvest. (Consult Forest Plan Chapter 4, Scenery Preparation: SCENE2 section.) For combined young-growth and old-growth projects within the same viewshed, apply the Very Low SIO. [SV, ML, TM]	Standards and Guidelines for Scenery are found in Chapter 4 of the approved 2008 Forest Plan under the Scenery section.	**S-YG-SCENE-01** is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	**S-YG-SCENE-01:** For young-growth harvests outside of Timber Production LUD, adopted Scenery Integrity Objectives for Each Land Use Designation shall be reduced by one level. (Consult Chapter 4 of the approved 2008 Forest Plan under the Scenery section There is no change to the SIOs for the Timber Production LUD. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	Identical to Alternative 1.

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Soil and Water (SW)				
Desired Conditions (DC)				
DC-YG-SW-01: Long-term soil quality and site productivity in the suitable land base is not impaired and is capable of supporting the regeneration, growth and successional pathways of naturally occurring plant communities. (Consult FSM 2554 Supplement No.: R-10 2500-2006-1.) Soil surface erosion and mass wasting from management activities is minimized. [OGH, SV, ML, TM]	Desired Conditions for Soil and Water are found in Chapter 4 of the approved 2008 Forest Plan under the Soil and Water section.	DC-YG-SW-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-SW-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	DC-YG-SW-01 is identical to Alternative 5. [SV, ML and TM LUDs only]
Guidelines (G)				
G-YG-SW-01: During timber harvest or vegetation treatment operations, dense slash and woody debris accumulations are not allowed. [OGH, SV, ML, TM]	Standards for Soil and Water are found in Chapter 4 of the approved 2008 Forest Plan under the Soil and Water section.	G-YG-SW-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	GS-YG-SW-01 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	G-YG-SW-01 is identical to Alternative 5. [SV, ML and TM LUDs only]
G-YG-SW-02: Ground-based yarding should avoid creating ruts that are more than 12 inches deep. [OGH, SV, ML, TM]	Guidelines for Soil and Water are found in Chapter 4 of the approved 2008 Forest Plan under the Soil and Water section.	G-YG-SW-02 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	G-YG-SW-02 is identical to Alternative 5. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	G-YG-SW-02 is identical to Alternative 5. [SV, ML and TM LUDs only]
Wildlife (WILD)				
Desired Conditions (DC)				
DC-YG-WILD-01: Active management of young-growth stands within the Old-growth Habitat LUD supports the integrated consideration of social, economic and ecological needs of regional and local communities. Young-growth stands within the Old-growth Habitat LUD maintain habitat and connectivity for wildlife and are managed to accelerate development of old-growth characteristics while also providing commercial timber byproducts. [OGH]	Desired Conditions for wildlife management in young-growth timber are found in Chapter 4 of the approved Forest Plan under the Wildlife section.	**DC-YG-WILD-01:** Non-development LUDs, maintain habitat and connectivity for wildlife at the landscape scale while also providing commercial timber byproducts. [OGH LUD only]	DC-YG-WILD-01 is identical to Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	Identical to Alternative 1.

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
DC-YG-WILD-02: In the Old-Growth Habitat LUD, treated young-growth emulates the natural scale and distribution of disturbance patterns (for example, wind-thrown timber that creates gaps and patches; landslides that create corridors and gaps; and mortality that naturally thins stands). [OGH]		DC-YG-WILD-02 does not apply.	DC-YG-WILD-02 does not apply.	DC-YG-WILD-02 does not apply.
Objective (O)				
O-YG-WILD-01: During the 15 years after plan approval, treat about 1,800 acres of young-growth in the Old-growth Habitat LUD to promote the development of old-growth characteristics while also providing commercial byproducts. [OGH]	Objectives for wildlife management in young-growth timber are found in Chapter 4 of the approved 2008 Forest Plan under the Wildlife section	During the 15 years after plan approval, treat about 3,200 acres of young growth in the Old-growth Habitat LUD to promote the development of old-growth characteristics while also providing commercial byproducts. [OGH LUD only]	During the 15 years after plan approval, treat about 2,200 acres of young growth in the Old-growth Habitat LUD to promote the development of old-growth characteristics while also providing commercial byproducts. [OGH LUD only]	Identical to Alternative 1.
Standards (S)				
S-YG-WILD-01: The maximum size of any created opening in the Old-growth Habitat LUD must not exceed 10 acres and a maximum removal of up to 35 percent of the acres of the original harvested stand is allowed. Commercial thinning is limited to 35 percent of the stand's original basal area. A combination of the two treatments may be used, with no more than 35 percent of the total stand removed in either basal area and/or acres. TTRA and other administratively withdrawn areas do not count towards the stand's total acreage. [OGH]	Standards for wildlife management in young-growth timber are found in Chapter 4 of the approved 2008 Forest Plan under the Wildlife section.	**S-YG-WILD-01:** Allow management of young growth stands to produce commercial wood products in all LUDs suitable for timber production. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	S-YG-WILD-01 is identical to Alternative 2. [OGH, RM, RR, SA, SM, SR, SV, ML and TM LUDs only]	Identical to Alternative 1.
S-YG-WILD-02: Commercial young-growth harvest within the Old-Growth Habitat LUD is limited to a one-time only entry unless best available scientific information shows that additional entries are: a) warranted, and b) meet the LUD objectives. [OGH]		S-YG-WILD-02 does not apply.	S-YG-WILD-02 does not apply.	S-YG-WILD-02 does not apply.

Table F-1.
Comparison of Young-Growth Direction by Alternative

Alternative 5	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Guideline (G)				
G-YG-WILD-01: Road construction should be kept to the minimum necessary for the removal of young-growth timber within the Old-Growth Habitat LUD. [OGH]	Guidelines for wildlife management in young-growth timber are found in Chapter 4 of the approved 2008 Forest Plan under the Wildlife section.	G-YG-WILD-01 is identical to Alternative 5. [OGH LUD only]	G-YG-WILD-01 is identical to Alternative 5. [OGH LUD only]	G-YG-WILD-01 does not apply.

Land Use Designations: Old-growth habitat (OGH); Remote Recreation (RM); Recreation River (RR); Special Interest Area (SA); Semi-Remote Recreation (SM); Scenic River (SR); Scenic Viewshed (SV); Modified Landscape (ML); Timber Production (TM).

APPENDIX G
TIMBER DEMAND AND SUPPLY

Appendix G

Tongass National Forest

Timber Demand and Supply

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Appendix G

Tongass National Forest Timber Demand and Supply

Susan Alexander, Ph.D., Program Manager
US Forest Service, Pacific Northwest Research Station

Nicole Grewe, Ph.D., Regional Economist
US Forest Service, Alaska Region

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Summary

Since 1990, when the Tongass Timber Reform Act (Public Law 101-626) required the Tongass National Forest to take economics into account in planning timber sale programs, multiple demand studies have been published by the US Forest Service Pacific Northwest (PNW) Research Station assessing derived demand for Alaska forest products. Demand assessment information is incorporated into short-term timber sale planning through a supply model and into long-term planning through the Forest Plan process. Appendix G supports Forest Plan amendment environmental impact statement (EIS) text, provides additional information regarding Daniels et al. (in press) demand estimates, and outlines how Daniels et al. (in press) demand projections are incorporated into annual timber sale offer target calculations for the Tongass National Forest.

Introduction

Section 101 of the 1990 Tongass Timber Reform Act (TTRA) states:

> Subject to appropriations, other applicable law, and the requirements of the National Forest Management Act of 1976 (Public Law 94-588), except as provided in subsection (d) of this section, the Secretary shall, to the extent consistent with providing for the multiple use and sustained yield of all renewable forest resources, seek to provide a supply of timber from the Tongass National Forest which (1) meets the annual market demand for timber from such forest and (2) meets the market demand from such forest for each planning cycle.

The 1997 Record of Decision for the Tongass Land and Resource Management Plan revision committed the US Forest Service to develop procedures to ensure annual timber sale offerings would be consistent with implementing TTRA's "seek to meet" market demand language. Those procedures were completed in 2000 and have become known as the "Morse methodology", in acknowledgement of the author, and are based on the following assumptions:

- Forest products markets are volatile, especially in the short term.
- Southeast Alaska timber purchasers have few alternative suppliers if they cannot obtain timber from the Tongass National Forest. Oversupplying this market has relatively few adverse economic effects; undersupplying it can have much greater negative economic consequences.
- It takes years to prepare national forest timber for sale, including completion of environmental impact statements.
- It is difficult to estimate Tongass National Forest timber demand, even a year or two in advance.
- To remain competitive, Alaska's forest products industry must be able to respond to rapidly changing market conditions.

The Morse methodology establishes a system that strives to build and maintain sufficient volume of timber under contract (i.e., timber purchased but not yet harvested – the primary indicator of timber inventory available to the industry) to allow the industry to react promptly to market fluctuations. Industry actions such as annual harvest levels are monitored and timber program targets are developed by estimating the amount of timber needed to replace volume harvested from year to year. The Morse methodology is self-correcting: if harvest levels drop below expectations, future timber sale offerings will also be reduced to levels needed to maintain the target level of volume under contract. Conversely, if harvest levels unexpectedly rise, future timber sale targets will also increase to ensure inventory of volume under contract is not exhausted. By dealing with uncertainty in a flexible science-based manner, the Morse methodology is an example of adaptive management. The US Forest Service intended for the Morse methodology to be the means by which the agency complies, year-to-year, with the annual demand portion of TTRA's "seek to meet" requirement. Similarly, the agency intended to comply with the requirement to seek to meet demand "for each planning cycle" through a series of annual applications of the Morse methodology.

During the past 25 years, the PNW Research Station has published several studies in support of Tongass National Forest land management planning that estimate derived demand for Southeast Alaska timber including Brooks and Haynes (1990, 1994, 1997), Brackley et al. (2006a), and Daniels et al. (in press). Procedures developed by Morse (2000) to estimate the timber offer target (supply) incorporate demand estimates from PNW studies as a spreadsheet input. PNW derived demand projections are trend projections. The Morse methodology relates these derived demand projections into an annual calculation of timber sale offer levels.

Procedures developed by Morse (2000) to estimate annual timber sale offering targets from the Tongass National Forest address the uncertainty associated with forecasting market conditions, considering the continuing transformation of the timber industry and the inability of the US Forest Service to respond quickly to market fluctuations due to the time it takes to prepare timber for sale. The basic approach is to allow the industry to accumulate an adequate volume under contract (i.e., a measure of inventory), then monitor industry behavior and adjust timber program levels to keep pace with harvest activity. Key economic indicators and stumpage market conditions are also monitored. Of noteworthy importance, the Morse methodology underwent rigorous technical and public review before it was implemented. Since the method was initially developed by Morse (2000), inputs to the model have been adjusted to reflect new understandings and information including share of raw material provided by the Tongass National Forest to local processors, amount of time between timber sale purchase and harvest, and sawmill capacity. In this way, the approach has allowed for adaptations to better reflect current conditions.

An update of the timber demand assessment by Brackley et al. (2006a) was requested from the PNW Research Station to inform new efforts to amend the Tongass Land and Resource Management Plan. New timber demand projections were also needed to accommodate changes in forest policy regarding Tongass National Forest timber harvest, land ownership, shipping policy, and profile of foreign log demand. PNW Research Station published new demand projections (Daniels et al. in press), in support of forest plan amendment efforts, with three alternative future scenarios. Scenario 1 incorporates the young growth transition and resulting changing quality of timber from the Tongass over time. Scenario 2 builds upon Scenario 1 by adding markets for wood energy products. Scenario 3 is motivated by uncertainty surrounding the domestic housing market and assumes a rebound in construction activity by only considering the pre-recession rate of growth in domestic lumber. New timber demand projections do not require significant change in the basic methodology for timber offer calculations in the procedure outlined by Morse (2000).

During the 1990s, competition with production in other regions and market conditions led to the closure of Southeast Alaska's two pulp mills and numerous other sawmill closures. From 2002 to 2006, the Tongass National Forest supplied approximately 65 percent of wood sawn by local sawmills (Kilborn et al. 2004; Brackley et al. 2006b; sawmill survey data collected by Dan Parrent of US Forest Service and on file with the US Forest Service Alaska Region). This percentage has increased in recent years with the Tongass National Forest providing an estimated three-quarters (78%) of wood sawn by local sawmills in 2013; nearly one-quarter (21%) of sawn wood originated from State of Alaska lands. State lands comprise a small percentage of Southeast Alaska forest lands and cannot indefinitely supply such a high

proportion of timber needed by remaining sawmills. A very small proportion (< 1%) of sawn timber has come from private lands in recent years. On average, the ten remaining local sawmills in the study operated at approximately 15 percent of their estimated capacity in 2013 (sawmill survey data collected by Dan Parrent of US Forest Service and on file with the US Forest Service Alaska Region).

The primary destination for Southeast Alaska sawn wood is other US states. Brackley and Haynes (2008) concluded many of the lumber and wood product markets Alaska sawmills compete in are higher-end markets in which foreign and domestic prices have become fairly similar, through market arbitrage. Haynes at al. (2007) found that since 1994, the value of US forest product exports has been in gradual decline while the value of imports has steadily increased. Hansen (2006) further states US companies have historically jumped into the export market when the domestic market is down – and shifted back to the US market when the domestic market improves. Haynes et al. (2007) state US demand for forest products is varied and large, averaging 71 cubic feet per person per year. Furthermore, per capita consumption of wood products in the US has been relatively constant for 50 years. Since the national recession (2007 – 2009) and prolonged period of economic recovery, the US market has been slowly rebounding with housing starts and forest product prices again on the rise. Global population growth will also drive increases in wood products demand both domestically and internationally.

In 2007, the US Forest Service in Alaska approved a new policy under which timber purchasers may ship to Lower 48 states unprocessed certain small-diameter and low-quality logs harvested from the Tongass National Forest, up to 50 percent of the volume harvested on each sale. This interstate shipment policy places purchasers of Tongass National Forest timber in a similar position as their counterparts in the Lower 48, where there is no restriction on interstate shipments of timber harvested from National Forest System lands. Implementation of this policy has made Alaska forest products producers more competitive with their counterparts in the Lower 48 states. Of noteworthy importance, the emergence of the Tongass National Forest as an international supplier of softwood logs is a major development since the prior demand study (Brackley et al. 2006a) that Daniels et al. (in press) incorporated into new demand projections.

On the supply side, the cost of preparing stumpage for sale and delivering it to sawmills has increased due to decreased size of sales, increased fuel costs, legal and procedural challenges to federal timber sales, and more constraints on harvest activity in the interest of resource protection. The uncertainty surrounding Tongass National Forest sale quantities has increased the risk faced by potential purchasers and investors in local processing capacity.

Demand Estimation

The method to project Alaska timber harvest and output followed by Daniels et al. (in press) is essentially the same as employed in previous estimates of Alaska timber demand by Brooks and Haynes (1990), Brooks and Haynes (1994), Brooks and Haynes (1997), and Brackley et al. (2006a). Derived demand is estimated by converting the volume of demand for Alaska forest products in all markets, foreign and domestic, to the timber volume required to produce those products. In the model, ratios are used to assign a portion of the total global demand to producing regions. Daniels et al. (in press) then estimate Alaska forest products output, by product, required to meet projected demand and calculate the raw material requirements necessary to support this production, using explicit product recovery and conversion factors. The total raw material requirement (i.e., total derived demand for timber) is a combined projection of timber harvest from private ownership, national forest, and non-national forest public owners. Projected national forest timber demand is the quantity of timber required to satisfy projected derived demand given harvest by other owners, explicit assumptions about markets, and implicit assumptions about prices. The study analyzes past trends over a period of nearly 25 years (1990 to 2013), which forms the basis for a 15-year projection (2015 to 2030) incorporating three key parameters:

1. The level of forest product imports in Canada and Pacific Rim nations. Daniels et al. (in press) define the Pacific Rim as Japan, Korea, and China. Based on other research regarding these markets, Daniels et al. (in press) projects imports of sawn wood products and softwood logs will increase over the next 15 years.

2. The share of Canadian and Pacific Rim markets that will be supplied by US forest products producers will remain relatively constant.
3. The share of US exports to Pacific Rim and Canada that will come from Alaska. Daniels et al. (in press) examines three alternative assumptions regarding future trends of Alaska's share of US exports to the Pacific Rim and Canada.

Daniels et al. (in press) assembled historic data describing relevant components of the Alaska forest products sector and calculated possible future wood needs by analyzing trends that influence harvests. They also used assessments of current markets from other analysts. Data from the historic period of 1990 to 2013 were used as the basis for projecting the future (2015 to 2030) to avoid overemphasizing short-term cycles. Trends in imports and consumption (for example, sawn wood in the Pacific Rim) and production trends represented by shipments (for example, lumber to all destinations) comprise the basic structure of the model. Demand for wood products is global in nature and the US is a net importer of timber. A sawmill in Alaska has the option to ship products to international export destinations, new markets in the Lower 48, or local Alaska purchasers. Price is the primary determinant of where products will be shipped. There are many high-value products (e.g., large timbers for architectural designed buildings and shop grades of lumber) that are shipped to the Lower 48 from Alaska. The vast majority of timber harvested in Alaska, however, is exported as softwood logs to Pacific Rim nations.

The demand model calculates the quantity of national forest timber needed by sawmills and exporters as a residual necessary to balance the model. In other words, Daniels et al. (in press) estimated the roundwood equivalent of all material used to produce products from Alaska and subtracted estimated future volume harvested from other landowners to derive national forest roundwood needs (i.e., the "residual"). Of noteworthy importance, the results in Daniels et al. (in press) reflect standing timber volume necessary to meet product demand from federal, state, and private lands.

Stumpage price projections in PNW Research Station demand studies are linked to price series used and projected in Resource Panning Act assessments (i.e., Haynes et al. 2007). Stumpage prices in Alaska are estimated as a function of Washington and Oregon prices. Alaska markets directly interact with producers and consumers in other US regions through this price relationship. Brackley and Haynes (2008) explain that "market arbitrage is used to understand parity among prices in spatially distinct markets where there is the opportunity for open exchange (trade). Market arbitrage is a powerful force that keeps prices of different species, grades, and locations within some fixed proportion to each other. Abstracting from transportation and transactions costs, for example, prices of one species and grade will not exceed prices for other species of similar grade in the long run because of possibilities of substitution." Tying price in Alaska to price in the Pacific Northwest is how market arbitrage is implicitly included in the demand assessment. The mix of products that enter end markets from Alaska are, on average, higher quality and more valuable than the average lumber markets in Washington, Oregon, and British Columbia (Brackley and Haynes 2008). The type of lumber products in the demand projections reflects this higher value by the type of markets they compete in. Although price is not explicit in the PNW Research Station demand studies, it is reflected through this mix of generally higher-value products that go into various end markets and by the assumption that Alaska price is a function of US price.

Southeast Alaska is one of the last places in western North America that produces products from slow-grown large old trees. Alaska's old-growth trees, and some younger trees, have special high-quality strength and appearance characteristics. Wood products manufactured in Alaska are generally destined for high-end markets, such as window casings and door moldings. These markets are arbitraged throughout the Pacific Rim, meaning prices for these products are similar regardless of what market it enters – domestic or foreign. Brackley and Haynes (2008) illustrate how Alaska producers have shifted in and out of domestic markets. Daniels et al. (in press) accounted for this market arbitrage by assuming export products would be synonymous with products that could be sold in domestic or foreign markets based on price.

Data regarding domestic end markets for sawn wood production from Southeast Alaska have been available since about 2000, however, information on domestic end markets can be difficult to verify. A major unresolved challenge is determining how much of the product shipped to the Pacific Northwest is

ultimately transshipped to another final destination. Transshipments are products that are shipped to foreign markets from a different customs district than the one in which they were manufactured. In the case of Southeast Alaska, lumber manufactured in Alaska is oftentimes shipped to foreign markets from the Seattle customs district, making it difficult to track many of the very recent end markets and subsequent demand for manufactured products from Alaska. Trade statistics for softwood log exports from Alaska are also confounded by transshipments. Other data used in the Daniels et al. (in press) analysis includes harvest of sawlogs and utility logs from all Southeast Alaska ownerships, production of lumber and other products from Southeast Alaska sawmills, log and lumber shipments out of Alaska to various destinations, Alaska market share of US forest products, and US market share in Canada and Pacific Rim nations.

Daniels et al. (in press) developed a baseline demand model, projecting from 2015 to 2030, to construct three scenarios representing alternative futures for timber harvest – all incorporating a transition from predominantly old growth to young growth timber harvest. The baseline demand model assumes projected trends in imports, consumption, and market share will remain constant. Additional assumptions include softwood log exports from all owners will continue at current five-year average, "other" production will remain constant, markets for utility logs and other low grade material will remain elusive, and the large majority of residues are sold. Alternative future scenarios reflect conditions related to changing timber quality, growing wood energy markets, and rebounding housing market demand.

> Scenario 1. The first scenario incorporates the young growth transition and resulting changing quality of timber from the Tongass National Forest over time. It includes a transition period of ten years of tapering levels of old growth harvest as the industry adjusts and more young growth becomes available. By 2025, old growth harvest will be limited to five million board feet annually for small and micro sales designed to provide raw material for small businesses and specialty products. Prior to 2025, scenario one reflects the baseline model.
>
> Scenario 2. The second scenario builds upon the first scenario by adding markets for wood energy products. It is US Forest Service policy to support the conversion from distillate fuel to wood-based energy in Southeast Alaska's residential, commercial, and industrial sectors. Expanding markets for biomass energy will impact Tongass National Forest timber harvest by generating demand for two biomass sources – sawmill residues and low- and utility-grade logs. Scenario two includes derived demand estimates as the conversion is phased in over time.
>
> Scenario 3. The third scenario is motivated by uncertainty in the US housing market – a traditional driver of global lumber demand. Notably, scenario three assumes a higher trajectory for the market by considering only pre-recession (prior to 2007) domestic consumption growth rates. During recent years, US sawnwood consumption levels have grown at levels nearly matching those of the pre-recession housing boom. The third scenario is based on the possibility that domestic sawnwood demand growth will continue at a pre-recession rate throughout the projection period.

Daniels et al. (in press) indicate there are several challenges with developing timber demand projections. Most notable is the lack of published market data for Alaska forest products. Their analysis was based primarily on two data sources – one of which only collects data from a predetermined set of sawmills. The second data source is a full census survey of sawmills, but is only completed every five years. Furthermore, because Southeast Alaska forest products industry is relatively small, issues related to confidentiality and disclosure further hindered data collection and analysis.

Using Derived Demand Estimates to Estimate Supply

Determining what demand estimates mean for timber sale offered from the Tongass National Forest involves taking the results from Daniels et al. (in press) and using them as input to a supply calculation that seeks to meet annual market demand from the forest. Derived demand projections in Daniels et al. (in press) are one of the inputs to the timber offer calculation developed by Morse (2000). In the development of the original model (Morse 2000), the derived demand input was total harvest volume, over time, from PNW Research Station projections developed by Brooks and Haynes (1997). Timber volume in the Daniels et al. (in press) demand projections, including scenarios one, two, and three, include export logs, lumber, residue, and "other" forest products (i.e., bowls, furniture, houselogs, molding, shakes, posts and poles, and siding). Table G-1 summarizes estimated sale volume represented by Daniels et al. (in press) in their projections.

Table G-1
Tongass National Forest Timber Sale Volume to Meet Derived Demand as Reported in Daniels et al. (in press)

	Projected Tongass National Forest Timber Harvest (MMBF; includes logs, lumber, residue, and other)		
Year	Scenario 1 Young Growth Transition	Scenario 2* Wood Energy Growth	Scenario 3* Housing Market Recovery
2015	40.9	40.9	40.8
2016	41.6	41.6	41.6
2017	42.3	43.4	42.5
2018	43.1	46.3	43.3
2019	43.8	49.2	44.1
2020	44.5	52.1	45.0
2021	45.3	55.1	45.8
2022	46.0	58.0	46.7
2023	46.7	60.9	47.5
2024	47.5	63.8	48.4
2025	44.0	63.0	45.0
2026	44.5	65.7	45.6
2027	45.0	68.4	46.2
2028	45.5	71.0	46.8
2029	45.9	73.7	47.4
2030	46.4	76.4	47.9

* Scenario 2 and Scenario 3 include the transition to predominantly young growth timber harvest (Scenario 1).

Demand numbers reported by Daniels et al. (in press) are projections of how much wood will be used to meet derived demand projections. Timber sales take years to process and can be held for several years by the purchaser in anticipation of future needs. Sales must be planned and timber made available in advance of projected needs. The derived demand projections do not include increased timber sale volume in anticipation of increases in wood processing (i.e., increasing use of existing infrastructure, construction of new sawmills). Additional timber to supply existing infrastructure operating at higher capacity or the construction of new sawmills would need to be sold in preceding years to provide sufficient timber supply.

Demand is an estimate, and translating that demand to on-the-ground sale numbers is also an estimate. The derived demand projections developed by Daniels et al. (in press) are used to estimate the market demand for the current Tongass National Forest planning cycle. They are also, as noted above, an important input to the model (Morse 2000) that the US Forest Service uses to compute the offer target or supply of timber from the Tongass National Forest in a given year. That procedure is outlined in the following section.

Development of Timber Sale Requirements to Meet Market Demand

New demand projections in Daniels et al. (in press) required that the spreadsheet model outlined in Morse (2000) for estimating timber sale goals be slightly modified to reflect the three alternative future

scenarios. Modification of the spreadsheet model allows continued implementation of Forest Service Sale Preparation Handbook direction (FSH 2409.18, R-10 Supplement 2409.18-2006-5; Ch. 11.4), which states that the procedure outlined in Morse (2000) will be followed in developing short-term offer targets.

The general approach of the timber sale offer model (Morse 2000) is to consider timber requirements of the region's sawmills at different levels of operation and under different assumptions about market conditions and technical processing capacity. These assumptions provide a basis for estimating the volume of timber likely to be processed by the industry as a whole in any given year. The specific steps in the process are outlined below.

Volume of Timber Processed Locally. The first step in the calculations adjusts sawmill capacity estimates by the utilization rate assumed for each of the three scenarios, and by the percent of volume expected to come from the Tongass National Forest. This provides an estimate of the volume of logs from the Tongass National Forest likely to be processed into lumber by sawmills in Southeast Alaska under the different scenarios. These figures are then adjusted upward to account for species and grades of timber that are not processed into lumber locally. Given this set of assumptions, the timber supply expected to be consumed in a given fiscal year is then computed.

Inventory Requirements. The second stage provides an estimate of the volume of uncut timber inventory to carry under different demand scenarios. As described on pages 19-20 of Morse (2000), target inventory levels depend on the volume expected to be processed each year and the amount of time needed to replenish inventory. The relationship is summarized in Morse (2000; equation 2, page 20) and by the timber inventory requirements in the model itself. Because the volume of timber expected to be processed varies by scenario, timber inventory requirements also vary from one scenario to another.

Harvest Projections. The next step in the process is to incorporate the derived demand estimates developed by Daniels et al. (in press), adjusted as shown in Table G-1.

Range of Expected Timber Purchases. By subtracting the volume under contract at the beginning of the year from the required inventory, the projected inventory shortfall is calculated. The low range of expected timber purchases is replacement for the volume harvested; the high range is the volume harvested plus the inventory shortfall so that the inventory requirement is met at the end of the year.

Between fiscal years 1999 and 2008, annual US Department of the Interior and Related Agencies Appropriations Acts allocated specific funds to the Tongass National Forest for the purpose of preparing a reliable timber supply. These "pipeline" funds were in addition to regular agency funding for forest management and timber sales. While "pipeline" funding varied by fiscal year, ranging from four to five million dollars, the objective remained the same – to establish a three-year timber supply to provide industry enough volume to maintain a viable inventory for financial integrity and to respond to market changes. While US Congress discontinued "pipeline" funding, the Tongass National Forest still strives to maintain a three-year timber supply.

Three-Year Timber Supply. The annual timber supply needs from the Tongass National Forest is considered synonymous with the annual timber consumption (i.e., the amount that is expected to be harvested in a given year). To estimate the three-year timber supply, the annual consumption is multiplied by three years.

Timber Pipeline. The Tongass National Forest timber pipeline was established as a process to "ramp-up" to the three-year supply over a period of years. It takes approximately four years to get a project through the analysis and preparation process – to be ready to offer for sale. The additional average annual volume needed to meet the three-year timber supply in a given fiscal year is the three-year timber supply of timber inventory minus timber inventory requirement, spread evenly over a four-year period.

Total Timber Sale Requirement. By taking the median between the low and high range of the volume expected to be purchased, and combining it with the average annual pipeline volume, the total volume anticipated for purchase is estimated.

The measure of meeting TTRA's "seek to meet" requirement while also developing a three-year timber supply is volume sold from the Tongass National Forest. To meet these objectives, a sufficient amount of

volume must be offered to account for any fall-down between the volume offered and the volume sold. The final step in projecting the amount of volume to be purchased is to evaluate the anticipated volume that needs to be offered.

Timber Sale Fall-Down. Historically, there has been a difference between volume offered and volume sold from national forest timber sales. The reluctance of purchasers to buy timber sales tends to increase as markets decrease and/or logging costs increase. Mason et al. (2004) examined why some offerings in Southeast Alaska go unsold and concluded that the probability of a timber sale being successfully sold is tied to downstream markets that are inherently difficult to predict rather than factors directly controlled by the US Forest Service.

Projected Offer Objectives. To project the amount of volume that needs to be offered for each of the alternative scenarios, the total timber sale projection is increased to account for fall-down and litigation to provide a rough estimate of the volume to be offered for each scenario to meet timber sale objectives.

Conclusion

Many challenges have confronted the Southeast Alaska forest products industry over the past two decades. Southeast Alaska's two pulp mills and numerous sawmill facilities have closed. Remaining active sawmills operate at about 15 percent of their estimated capacity, on average. During 2013, the Tongass National Forest supplied approximately three-quarters of logs for local sawmills followed by one-quarter from state land; less than one percent is from private lands. The destination for material sawn in Southeast Alaska is now primarily other US states (Kilborn et al. 2004; Brackley et al. 2006b; Backley and Crone 2009; Alexander and Parrent 2010, 2012). Demand for Southeast Alaska sawnwood products in export markets continues to be relatively low, while exports of softwood logs have remained strong. Hansen (2006) states US companies have historically jumped into the export market when the domestic market is down, and shifted back to the US market when the domestic market improves. In recent years, the US domestic market has been attractive with rising housing starts and forest product prices.

On the supply side, the cost of preparing stumpage for sale and delivering it to sawmills in Alaska is generally higher than in Oregon and Washington, due to transportation and labor costs, decreased timber sale size, increased fuel costs, legal and procedural challenges to federal timber sales, and more constraints on harvest activity on federal lands in the interest of resource protection. The uncertainty surrounding Tongass National Forest sale quantities has increased the risk faced by potential purchasers and investors in local processing capacity.

In choosing the timber sale offer level, it is important to anticipate the consequences of decisions. In terms of short-term economic consequences, over-supplying the market is less damaging than under-supplying it. If more timber is offered than purchased in a given year, the unsold volume is still available for purchasing off-the-shelf or re-offered at a minimal investment. However, a significant shortfall in timber supply available for harvest can be financially devastating to the industry.

The purpose of this paper is to identify the extent to which economic analysis contributes to this decision-making process. In the final analysis, planning a timber sale program is an exercise in professional judgment and needs to consider more than economic factors. Realistic timeframes account for delays in timber sale preparation, administrative appeals, and/or litigation with sufficient contingent volume included in the annual timber sale program. Budget and organizational constraints also limit the extent to which the US Forest Service can respond to economic cycles and associated fluctuations in timber demand. These are all important considerations in evaluating market demand for timber and setting timber offerings.

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APPENDIX H
LIMITED EXPORT POLICY

Appendix H
Alaska Limited Export

The concerns raised in public comment that log exports reduce the number of local jobs are not new and are not unique to the Tongass National Forest. Reviewers claim timber export employs fewer people than are required to process wood products domestically, or in this case, in Southeast Alaska. As a result then, fewer manufacturing facilities are built to process timber domestically, or within Southeast Alaska. Historically, those arguments have been effective in raising public concern and have resulted in legislation restricting exports since the 1930s. However, it has been long recognized that special circumstances exist in Alaska such that limited export allowance of forest products from the Tongass actually works to maintain local industry. Accordingly, the Forest Service allows, but appropriately limits, the export of unprocessed timber from National Forests in Alaska under general authority of the Organic Administration Act,[1] National Forest Management Act (NFMA),[2] and 36 Code of Federal Regulations (CFR) 223.201.

One of the primary goals of the Tongass National Forest timber program is to contribute to the local and regional economies of Southeast Alaska. In keeping with this long-standing goal, current law allows timber harvested from federal lands in Alaska to be shipped out of Alaska only if "the supply of timber for local use will not be endangered."[3] In 2007, the Forest Service Region 10 approved a Limited Export Policy in an effort to boost appraised values and provide purchasers economical sale opportunities and additional processing options. In this case, such shipments actually increase the utilization of timber harvested on the Tongass because it allows local sawmills to make a profit when they purchase timber sales, keeping loggers, road construction crews, transporters and sawmill workers employed. These goals remain on the Tongass today, and will be especially important as the Tongass National Forest accelerates the transition to young-growth harvest.

Background

For over 100 years, numerous laws, regulations, and policies have imposed varying degrees of export restrictions on timber harvested from Alaska federal lands. The common thread and purpose has always been to sustain the local timber industry. From the beginning, the 1897 Organic Administration Act prohibited interstate export of national forest timber.[4] However, in departmental appropriations acts from 1917 to 1926, Congress granted the Secretary of Agriculture the discretionary authority to allow interstate exports.[5] The 1926 Exportation of Timber Act permanently codified this Secretary's authority to allow interstate exports of National Forest System (NFS) timber if, "in the judgment of the [Secretary of Agriculture], the supply of timber for local use will not be endangered thereby."[6]

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[1] Organic Administration Act of 1897 (Organic Act), Act of June 4, 1897, ch. 2, 30 Stat. 11, 34-36 (codified as amended at 16 U.S.C. §§ 473-482, 551 (2000)).
[2] National Forest Management Act of 1976, 16 U.S.C. §§ 1600, 1611-1614 (2000) (amending Forest and Rangeland Renewable Resources Planning Act of 1974, Pub. L No. 93-378, 88 Stat. 476).
[3] 16 U.S.C. § 616 (1960) (originally enacted in 1926). Further detail on implementing this requirement is provided by regulations found at 36 C.F.R. 223.201.
[4] Organic Administration Act of June 4, 1897, Ch. 2, 30 Stat. 11, as amended; 16 U.S.C. §§ 473-475, 477-482, 551. The Act of May 14, 1898 extended the homestead laws to Alaska, and authorized the sale of timber from public lands in Alaska for use only within the Territory.
[5] 16 U.S.C. § 461 (1960).
[6] 16 U.S.C. § 616.. Local use, the primary qualifier for future regulating decisions, was later interpreted as "the supply of timber for local consumptive use rather than the supply of timber to meet the needs of local mills processing timber for non-local markets as well as local markets." *See* Brief Summary of General Counsel's Memorandum of July 10 in Reply to the Questions Submitted by Senator Morse of Oregon relative to the Secretary's Authority to Sell Timber from the National Forests for Export. [Date unknown]. Washington, DC: U.S. Department of Agriculture, Office of the General Counsel: 4. This interpretation remains the primary authority regarding timber sales from National Forests in Alaska.

In 1928, the Secretary exercised his discretion and permitted export from all States, except from the Territory of Alaska.[7] The prohibition on the export of logs from Alaska originated in a 1928 memorandum from then Regional Forester W.B. Greeley who sought to promote development of Alaska's pulp and paper industry by requiring primary manufacture of high-grade Sitka spruce and hemlock to bolster the value of lower-value material for the pulp and paper mills. The prohibition of raw log exports from Alaska did not appear in federal regulations until 1946, where discretionary authority was expressly granted to the Chief of the Forest Service to consent to export allowances for certain product considerations.[8] Those regulations were again modified in 1974 to delegate exclusive approval authority to the Alaska regional forester.[9] The regulations, still in effect, recognize Alaska's unique circumstances by allowing national forest lands timber purchasers, who cannot locate a buyer in their market area, to apply for an export exemption:[10]

> ***36 CFR 223.201 Limitations on Unprocessed Timber Harvested in Alaska***
> *Unprocessed timber from [NFS] lands in Alaska may not be exported from the U.S. or shipped to other States without prior approval of the Regional Forester. This requirement is necessary to ensure the development and continued existence of adequate wood processing capacity in Alaska for the sustained utilization of timber from the National Forests which are geographically isolated from other processing facilities. In determining whether consent will be given for the export of timber, consideration will be given to, among other things, whether such export will: a) permit more complete utilization on areas being logged primarily for local manufacture; b) prevent loss or serious deterioration of logs unsalable locally because of an unforeseen loss of market; c) permit the salvage of timber damaged by wind, insects, fire, or other catastrophe; d) bring into use a minor species of little importance to local industrial development; or e) provide material required to meet urgent and unusual needs of the Nation.*

Several other special accommodations recognizing the circumstances in Alaska have been made.[11] For example, another disadvantage for Alaska is that the available old-growth is often defective, with over 50 percent of some harvests unsuitable for sawing and therefore of limited market value. Because the local sawmills did not have the capacity to utilize the volume of chips produced from national forest timber, in 1977 the Forest Service removed the export ban of chips, effectively expanding market opportunity for the sale of chips made from those defective logs.[12] Similarly, export of salvage materials were expressly allowed to boost the local industry during the early 1980's global recession that depressed timber prices.[13]

Another hurdle for the Alaska timber industry is that no timber sale on the Tongass National Forest may be advertised if the appraised value is deficit when using residual value appraisal and red cedar domestic processing. This restriction was first imposed by Section 318 of the Consolidated Appropriations Resolution, 2003 (Public Law 108-7), with identical language included in subsequent annual appropriations acts. [14] In 1969, yellow cedar was declared (by both Secretaries of Agriculture and Interior)

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[7] The Secretary has consistently interpreted 16 U.S.C. § 616 as authorizing the conditioning of export upon primary manufacture within the State of Alaska. *See also* 36 C.F.R. 221.25(g) (1970)).
[8] Lane, Christine L. 1998. *Log export and import restrictions of the U.S. Pacific Northwest and British Columbia: past and present*. Gen. Tech. Rep. PNW-GTR-436. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.
[9] 36 CFR 223.161 (1974) (current version at 36 CFR 223.201).
[10] 36 CFR 223.201.
[11] Lane, Christine L. 1998. *Log export and import restrictions of the U.S. Pacific Northwest and British Columbia: past and present*. Gen. Tech. Rep. PNW-GTR-436. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.; i.e., substitution does not apply to Alaska (U.S. Department of Agriculture, Forest Service, Alaska Region. 1987. USDA Forest Service Manual; Alaska Region Supplement 275).
[12] Lane, Christine L. 1998. *Log export and import restrictions of the U.S. Pacific Northwest and British Columbia: past and present*. Gen. Tech. Rep. PNW-GTR-436. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Federal Register. 1977. Vol. 42, No. 129. Wednesday, July 6.
[13] Lane, Christine L. 1998. *Log export and import restrictions of the U.S. Pacific Northwest and British Columbia: past and present*. Gen. Tech. Rep. PNW-GTR-436. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.
[14] Most recently as part of the Carl Levin and Howard P. 'Buck' McKeon national Defense Authorization Act for Fiscal Year 2015, Public law No. 113-291, December 19, 2014, 128 Stat. 3729, section 3720(e)(4).

surplus to Alaska domestic manufacturing needs and continues to be freely exportable to foreign markets. Section 318 allowed red cedar to be shipped to the Lower 48 when local domestic markets do not exist. Because, before 2007, the Alaska Region only approved out-of-state shipments on a case-by-case basis after the sale, the appraisals (developed before the sale) assumed that all timber except Alaska yellow cedar would be processed in Alaska. The list of export policy changes spanning 100 years is long, but the clear focus throughout this time has been on the need to ensure the development and continued existence of adequate wood processing capacity for the sustained utilization of timber.

Section 705(a) of the Alaska National Interest Lands Conservation Act (ANILCA), as amended by Section 101 of the Tongass Timber Reform Act (TTRA), also guides the timber program on the Tongass. TTRA provides that the Secretary of Agriculture shall "…seek to provide a supply of timber from the Tongass National Forest which (1) meets the annual market demand for timber from such forest and (2) meets the market demand for timber from such forest for each planning cycle." Although all national forests are required to estimate demand for timber during forest planning efforts, the "seek to meet" requirement is unique to the Tongass National Forest.

Alaska Region Limited Export Policy

In keeping with the regulations cited above, shipment outside Alaska of unprocessed timber from NFS lands requires prior approval by the regional forester. Historically, such approvals were granted on a case-by-case basis at the request of the purchaser after the sale was awarded. The Forest Service began analyzing the benefits and potential impacts of easing the export restriction on the Tongass as early as 1978.[15] As timber prices fell dramatically in response to the so-called Great Recession of 2007 to 2009 and prolonged period of economic recovery, the Forest Service recognized that because Alaska is far from most of its markets, it is the first to suffer in a recession and the last to benefit from economic recovery.

The wood products market crises made it difficult for the Forest Service to offer timber that would appraise positive, yet Section 318 prohibits the Forest Service from offering sales that do not. Timber values are lower in Alaska than elsewhere, largely due to higher operating and transportation costs in Alaska.[16] Even if deficit sales could be offered, doing so would not be economically viable in the long run, since the purchasers would most likely lose money on them.

Non-federal lands adjacent to the Tongass National Forest have no log export restrictions so the Tongass National Forest has historically been the major supplier of timber to local sawmills. Unless the Tongass National Forest can offer a reliable supply of timber with a positive appraisal, the few remaining locally-owned sawmills in Southeast Alaska would find it very difficult to stay in business. Closure of the remaining sawmills, even on a temporary basis, would run counter to the objective of supporting local economies and wood processing capacity in Southeast Alaska.

Because Southeast sawmills do not have extensive supplies of timber available, even a short-term hiatus in offering sales from the Tongass National Forest could result in losses from which the sawmills, the rest of the timber industry in Southeast Alaska, and the entire Tongass timber program might never recover. Once a sawmill shuts down, re-opening becomes more difficult over time, as skilled employees find other jobs, equipment becomes obsolete or is sold, and capital becomes more difficult to obtain. Cessation of the program and the related private-sector activities would have very noticeable adverse consequences in several local economies across Southeast Alaska.

[15] Darr, David R. 1978. *Potential Impact of Easing the Log Export Restriction on the Tongass National Forest*. USDA Forest Service Resource Bulletin PNW-77. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, available at http://www.fs.fed.us/pnw/pubs/pnw_rb077.pdf (citing the 1969 recommendation of the Public Land Law Review Commission to ease the export restriction to allow higher stumpage revenues).
[16] Alaska Dept. of Labor. *Alaska Economic Trends*, at 11 (Dec. 2003), available at http://labor.alaska.gov/trends/dec03.pdf.

The Forest Service recognized appraisals of proposed Tongass timber sales would rise if they assumed that a portion of the unprocessed Sitka spruce and hemlock logs were to be shipped to lower 48 markets, such that timber sale appraisals would reflect beneficial pricing in markets outside of Alaska. That assumption would be possible if shipments were approved prior to the sales being appraised, instead of authorizing shipments only after the timber is sold. Allowing routine interstate shipment of a portion of unprocessed Sitka spruce and hemlock logs from Alaska provides Alaska operators the opportunity to capture some of the economic efficiency available from the vertical integration (*i.e.* consolidation) that exists in the lower 48. This approach would also lower some of the operating and transportation costs that are deducted from selling prices in the appraisal calculations. Between the higher prices and lower costs, limited interstate shipments significantly increase the likelihood that timber sales in parts of the Tongass would have a positive appraisal under poor market conditions. Such shipments would also increase the utilization of timber harvested on the Tongass.

Consequently, the Forest Service analyzed seven limited export scenarios it designed to establish a programmatic approach that would best meet the following objectives:

1. Ensure that economic timber sales can continue to be offered from the Tongass National Forest.
2. Ensure the continuation of wood processing capacity in Alaska.
3. Minimize the amount of unprocessed logs being shipped outside of Alaska.
4. Maximize employment in the United States from timber harvest activities conducted on the Tongass.

It is important to recognize that, to some degree, these are competing objectives. For example, if the first objective were all that mattered, positive appraisals could be achieved by allowing all logs to be shipped out-of-state without any in-state processing. That approach would result in positive appraisals under most market conditions in most areas of the Tongass, so timber could continue to be offered for sale. It would not, however, support continuation of Alaska's wood processing capacity or minimize the shipment of unprocessed logs out-of-state Likewise, if the third objective were all that mattered, it could be accomplished by not allowing any shipment of unprocessed logs outside of Alaska. As described above, however, that approach would soon prevent many Tongass sales from being offered, which would endanger the continuation of wood processing capability rather than ensure it. Without a reliable supply of timber from the Tongass, the remaining locally-owned sawmills would probably be forced to close.

Consistent with the results of that analysis, in 2007 the Alaska regional forester adopted the *Limited Export Policy*, intended to boost appraised timber values, provide economic sale opportunities for purchasers, and provide additional processing options for purchasers. The policy modified how timber sales were appraised and allowed timber purchasers options on shipping certain small diameter logs from national forest timber sales to the Lower 48 states. Designed to allow flexibility for timber purchasers, the Limited Export Policy was not, nor is today, something mandated by the Forest Service on a timber purchaser or automatically or immediately applied to all timber sales. Rather, the policy is applied by request of the timber purchaser after the contract offering is awarded or any time thereafter.

The Limited Export Policy established a programmatic limited approval for export so that total shipments of unprocessed logs outside of Alaska were limited to no more than 50 percent of the total volume of all species harvested on each sale. This included shipments of western red cedar to the Lower 48 and exports of Alaska yellow cedar to foreign markets. Requests to ship more than 50 percent of the total volume of a sale out of Alaska continued to be considered on a case-by-case basis.

Restrictions on the out-of-state shipment of unprocessed logs were put in place, among other things, to ensure the continuation of wood processing capability in Alaska. The programmatic limited approval of interstate shipments achieved that result by increasing the Forest Service's ability to design sales with greater utilization and a positive appraisal.

In recognizing that the Limited Export Policy is intended to support local manufacturing in down markets, the Limited Export Policy is reviewed on an annual basis to determine whether it should be adjusted or discontinued. Since 2007, the policy has continued, with modifications, which have provided additional options for purchasers while maintaining goals established by the Agency. Although improvements to markets have occurred since 2007, challenges continue for purchasers seeking domestic markets for Alaska timber.

After a year of implementation, it became clear that the interstate shipment of unprocessed Sitka spruce and hemlock did not offset costs for fuel, barging/shipping, insurance, and manufacturing being experienced by Southeast Alaska's timber industry. A corresponding decline in orders and values for wood chips in the Lower 48 states, coupled with 12 consecutive quarters of decline in the softwood lumber indices, threatened the viability of the timber industry, and dependent Southeast Alaska communities. Thus, in 2008 the regional forester responded to industry request by expanding the scope of the policy to also allow foreign export in 2008 for existing contracts if a premium was paid for certain species. The policy was again expanded in November 2009 to apply to all contracts and allowed export of unprocessed Sitka spruce and hemlock logs, up to 50 percent of the total sale sawtimber volume, to be shipped to the most advantageous markets. At that time, a foreign market appraisal was established for use on timber sales to reflect export values for Sitka spruce and hemlock.

In 2011, the policy was expanded to consider applications on settlement sales. Beginning in 2012, in a continuing effort to encourage and support domestic processing, the regional forester agreed to begin reviewing requests to allow increased export of Western hemlock and Sitka spruce from sales where an approved export permit was already in place. This increase in export has been approved on a case-by-case basis, in exchange for purchasers providing an equivalent amount of Alaska Yellow Cedar to small business operators who would process the timber locally. In 2014, the regional forester approved a rebate for young-growth Sitka spruce when timber had been appraised for export, but primary manufacture occurs in Alaska.

The regional forester noted in the 2015 review that, while improvements occurred nationally over the past three years, challenges continue for purchasers seeking domestic markets for Alaska timber. As a result of this review, the Limited Export Policy remained in place for calendar year 2015. The current residual value appraisal allows a higher percentage of volume to be appraised for domestic processing, when indicated advertised values are very positive for a planned sale offering. Domestic processing is encouraged when a perceived opportunity exists. For example, sales with greater quantities of large diameter hemlock and Sitka spruce volume may be profitable for processing locally (i.e., > 20 inches for hemlock and > 18 inches for Sitka spruce). Hemlock and Sitka spruce volume approved for export that has not been appraised using the residual value appraisal have a premium fee requirement of $40/MBF for shipment of these species out of Alaska. The regional forester also continues to encourage and support domestic processing by considering requests on a case-by-case basis, to allow increased export in exchange for equivalent volume supplied directly to small local operators who would process the timber locally.

The Limited Export Policy was developed under existing authority, which up until 2007 had been exercised only on a case-by-case basis; the only difference is to grant such limited authority for interstate shipments of unprocessed Sitka spruce and hemlock logs on a programmatic basis applicable to all sales across the Tongass. The Forest Service undertook notice and comment rulemaking in adopting regulations allowing the limited export of forest products in Alaska, as well as in granting this authority to the Alaska regional forester. The Limited Export Policy represents the exercise of the regional forester's express authority to provide "prior approval" for limited export allowances consistent with the regulation. The establishment of a programmatic policy was needed to ensure the continued existence of adequate wood processing capacity in Alaska. The policy also permits more complete utilization of small diameter and low grade logs which cannot be profitably processed in Alaska. By limiting export of unprocessed Sitka spruce and hemlock logs to no more than 50 percent of the total sale sawtimber volume, the policy

ensures that the Tongass timber program will continue to be operated primarily for local manufacture. The 2007 Limited Export Policy is reviewed on an annual basis and adjustments have been made reflecting the current needs of the industry based on that review. As the young-growth transition proceeds, additional policy changes may become necessary to align with market developments.

Effects Analysis

The authorization for limited interstate shipments of unprocessed Sitka spruce and hemlock logs may increase the amount of harvest on the Tongass above the amount that could occur without it. This is the case because with the positive appraisal requirement, many sales would not be offered if not appraised for export. However, in order to ensure that timber sale offerings are consistent the agency's obligations under TTRA, timber sales must be offered so long as there is a demand for Tongass timber. The Limited Export Policy provides flexibility for the region to balance the economics of timber sales to meet both of those statutory requirements.

While it may be the case that more timber is cut than without the policy because sales would not appraise positive and could not be offered, this does not increase the amount of timber harvested beyond that analyzed and disclosed pursuant to the National Environmental Policy Act (NEPA), NFMA, and the Administrative Procedures Act. The policy itself has no environmental effects—implementation of the policy involves further Forest Service action, which is subject to NEPA analysis, including public notice and opportunity for comment.

NEPA analysis of the effects of the Limited Export Policy has been conducted at both at the programmatic and site-specific levels since its adoption. While analysis at the forest plan level assists the agency in selecting among management alternatives, the forest plan itself also does not authorize the harvest of timber without further, site-specific NEPA review. Project-level NEPA analyses evaluate the effects of timber sales in light of the policy including potential effects on in-state employment and the financial efficiency of project alternatives. Project-level NEPA documents also describe how each specific timber sale meets the TTRA requirement to seek to meet market demand for Tongass timber while also providing for the multiple use and sustained yield management of the Forest's renewable resources.

When it was adopted, the Limited Export Policy was also applied to projects already approved but not yet fully implemented. In each of those cases, an evaluation was completed to determine whether limited interstate shipments of unprocessed timber would meaningfully change the environmental effects of the project in a manner that was relevant to issues that were factors in the NEPA analysis and decision. Such determinations were and continue to be rare, because the environmental effects of timber harvest activities do not materially change as a function of where the timber is processed.

Timber sales are sold to purchasers with different business goals and ever-changing markets. Historically, the percentage of the volume harvested on the Tongass that has been shipped out-of-state has fluctuated so it is not possible to precisely predict what will be manufactured locally. Therefore, a range of employment and income figures is considered the most reasonable approach to display potential effects of the policy on jobs and income. Most of the purchasers, since they are trying to make a profit, want to optimize the value of their products and use export as a means to do this. At the present time, some of the volume from larger sales is shipped out of state to optimize the return to the purchaser. Information on the amount of volume exported from 2001 to 2015 is located on the Tongass website (http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3845620.xlsx) and shows an annual range of 2.7 MMBF to 19.5 MMBF. The highest volume reflects a 2005 salvage sale from the Yakutat Ranger District, the value of which the Forest Service wanted to ensure was captured before the wood decayed. On average, export represented only 28.2 percent of what was harvested during that period. Thus, an average of 71.8 percent of the timber harvested on the Tongass National Forest over the last 15 years received primary manufacture in Alaska sawmills.

Estimated employment is analyzed and presented as a range based on the existing Limited Export Policy. Direct employment and income estimates are presented as a range in the 2016 Forest Plan Amendment Final Environmental Impact Statement (FEIS) in Table 3.22-19. These estimates are for employment that would take place in Southeast Alaska. Although estimates of value for timber in the various alternatives are based on maximizing shipments of timber sold out of state (Table 3.22-17), purchasers have the choice to sell as much as they can to other markets as allowed under the Limited Export Policy, or process part or all of the material in local sawmills. Actual employment and income in Southeast Alaska would depend on choices made by purchasers; those choices may change as markets and prices shift. Under current market conditions, purchasers are likely to export as much as they can while processing enough material locally to keep manufacturing facilities open, and take advantage of opportunities to produce high-value sawn material in Southeast Alaska.

Transportation and other services include water transportation, independent trucking, stevedoring, scaling, and export marking and sort yard employment for export volume, and water transportation, scaling, and independent trucking for locally-sawn volume. Export employs more workers in transportation and other services per MMBF harvested than domestic production. This is reflected in the range of values presented in the FEIS.

When the Limited Export Policy was adopted in 2007, the Forest Service utilized the NEPA Economic Analysis Tool-RV (NEAT-R) model to analyze the policy potential effects on employment to aid the agency in selecting among various alternatives in its NEPA analysis. NEATR calculated jobs in two categories: logging and sawmill. Following adoption of the policy, sawmill jobs were presented as a range, representing 50 to 100 percent domestic processing. The job calculation for 50 percent export assumed a 50 percent reduction in sawmill jobs, but did not consider that export supported transportation-related, as well as logging jobs. In March 2011, the Forest Service implemented a new model, known as the Financial Analysis Spreadsheet Tool-RV (FASTR), which addressed this shortcoming by estimating jobs in four categories: logging, sawmill, transportation related to domestic manufacturing, and transportation related to export. The model estimates jobs and associated income by utilizing annual trend-based employment information collected by the agency from 2007 to 2010. These annual sawmill surveys continue to inform the employment coefficients assigned to job categories in the FASTR model.

As described in the Plan Amendment FEIS, the analysis presents a range for annualized sawmill jobs which reflects the range of export options that may be available to a timber sale purchaser. The employment and income analysis in the FEIS assumed a range from maximum possible shipment out of state (export of all Alaska yellow cedar plus hemlock and Sitka spruce export equal to 50 percent of total sale net sawlog volume), to no shipment of hemlock and Sitka spruce and export of 100 percent of Alaska yellow cedar (see Table 3.22-19 in the FEIS). It may overestimate the low range since the volume that can be shipped is limited to certain species and grades unless exemptions are approved by the current export policies. The analysis in the FEIS also presents employment and income estimates for this range.

The assumptions used with respect to the Limited Export Policy for the financial, employment, and income analyses are appropriate for programmatic analysis. Additional analyses will be conducted as part of the project-specific environmental analysis that will be prepared as part of future timber sale projects, as done since the Limited Export Policy was adopted. These analyses take into account the Limited Export Policy as well as any other potential restrictions on export or production in place at that time.

While the current policy allows case-by-case consideration for export in quantities beyond that which is programmatically approved by the regional forester, for the purposes of the programmatic analysis, it is reasonable to evaluate the upper limit as prescribed by the current version of the Limited Export Policy. If purchasers were allowed on a case-by-case basis to export a larger share of a particular sale in unprocessed form, there would be a commensurate reduction in sawmilling jobs and an increase in transportation-related jobs. This is explained in the Plan Amendment FEIS. In such cases, the agency undertakes analysis to determine the significance of the change.

The information presented in the Plan Amendment DEIS reflects the current industry and recent trends that are operating in Southeast Alaska. It is not intended to illustrate the full extent of the reduction in wood products employment that has occurred since it peaked at 3,543 jobs in 1990. At that time, there were two 50-year contracts that guaranteed a steady supply of timber. These long-term contracts involved supplying two pulp mills, which required a large workforce both to supply and operate the mills. A more complete explanation of the timber industry since 1990 is in the 2008 Forest Plan Amendment FEIS, p. 3-499 to 3-511.

Looking Forward

In 2010, the US Department of Agriculture announced a “Transition Framework” Policy aimed at diversifying the Southeast Alaska economy and shifting the timber industry to young-growth harvest and management. In 2013, Secretary Vilsack announced the Department’s goal “to effectuate this transition over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young-growth.” Since that time, the US Forest Service, USDA Rural Development, local businesses, conservation groups, and others have been evaluating how the region can develop a locally-based, properly-scaled young-growth industry that provides greater economic security for local communities, builds regional knowledge and skillsets, and restores critical forest habitat in the Tongass.

The agency has the authority to amend the forest plan to accelerate the transition to young-growth, which is one step in addressing sustainable forestry in Southeast Alaska. Additional steps in the Tongass Advisory Committee’s (TAC) detailed transition implementation recommendations provide guidance on elements for success in implementing the transition, and identify opportunities by which the agency, stakeholders, and greater community will share ownership of the transition strategy and embrace its successful implementation. The work done by the TAC offers the possibility of a regionally focused, collaborative path toward an innovative opportunity for a viable young-growth timber industry while honoring the suite of economic, ecological, social, and cultural values inherent in the forest. The TAC provided detailed recommendations for targeted investment, financial assistance, and financing mechanisms for stand inventory, research, infrastructure, and retooling. These investments are intended to help communities and businesses successfully transition to, and thrive within, a new young-growth economy.

A recent report by Government Accountability Office (http://gao.gov/products/GAO-16-456) outlines additional steps taken or planned by the Forest Service, including comparing potential market prices for young-growth timber or products to the cost to harvest, transport, and process the timber; refining of young-growth timber data; lengthening the duration of small sale contracts to provide small sawmill owners with flexibility; and expanding collaborative projects to support job creation through sustainable forest management and improve predictability of timber supply.

It is important to retain the expertise and infrastructure of the existing industry to allow businesses the opportunity to quickly retool. These businesses are fundamental to both the young-growth and restoration components of the future timber program, and to the economic vitality of the region. The Forest Service will continue to offer a supply of old-growth while increasing the supply of young-growth to provide the industry the opportunity to develop new markets, learn new skills, and acquire new equipment. This will include offering old-growth timber sales like the Big Thorne timber sale to provide “bridge timber, as well as continuation of the micro-sale programs and old-growth small sale program which target niche markets. In addition, young-growth timber sales may include old-growth to help boost appraisal values of young-growth sales until a reliable supply of economically viable young-growth may be established. It has been acknowledged since 2000, that the transition to young-growth in Southeast Alaska would be shortened and more abrupt because less unmanaged second growth, which has characteristics

intermediate between old-growth and young-growth, is available to ease the transition.[17] This is why bridge timber is a critical factor to maintain a viable industry while the transition takes place.

Successfully transitioning the Tongass timber sale program from one based on old-growth to young-growth is dependent on a range of economic, social, and ecological factors, not all of which are under Forest Service control. Since the closure of the pulp mills, there is no local market for lower-grade materials that historically supplied the mills. Without the opportunity to export these products, utility and lower grade materials would be left in the woods. Allowing export of these materials which have no local market allows for more complete utilization of Tongass National Forest resources. Similarly, in the early years of the transition it may be the case that there is a very limited local market for young-growth logs. In order to keep local operators in business, young-growth timber sale purchasers will have the option to export those logs which cannot be locally utilized, consistent with the Limited Export Policy. As the Forest Service builds the capability to provide a reliable supply of economically viable young-growth timber, local processing capability is expected to develop to utilize the material that has formerly been left in the woods or is currently being largely exported.

The agency's long-range goal to ensure that Tongass timber is available primarily for local and domestic processing is a priority, in order to create more local economic benefits. Therefore, a glide path of increasing supply of young-growth gradually over time makes sense. Alternatively, young-growth might be entirely exported, a scenario that may not result in the same amount of local economic and community benefits. However, consistent with existing authority to allow export of forest products from public lands, export allowances may not endanger the supply of timber for local use. As shelf volume for young-growth becomes available as the young-growth ages and the economics and market demand become more favorable, industry can re-tool. As the local demand for young-growth grows, the export of unprocessed young-growth logs should taper down so as to provide a supply of Tongass timber for local use. The transition is not expected to "generate jobs" but rather support existing jobs. Once the timber supply reaches a long-term stability above the needs of the current operators, other timber industry operators may move into Southeast Alaska. Currently, those purchasers that have been interested are discouraged by the lack of a stable timber supply.

The 2016 forest plan amendment FEIS was designed to analyze the feasibility of shifting from an old-growth forest management regime towards young-growth management on an accelerated timeline, so that within 10 to 15 years the vast majority of timber sales on the forest will be from young-growth forests. How rapidly and effectively this is accomplished depends on local support from Alaska markets for young-growth forest products. The ability to export some timber beyond Alaska may serve as a strategic option that can be used to help maintain workforce skills, industry expertise, and the physical infrastructure needed to develop a future young-growth industry. The Limited Export Policy will continue to be subject to review and modification on an annual basis, as noted above.

Although the Tongass young-growth resource is several years away from being able to support a region-wide industry, local harvesters, processors, builders and others are already building the skills, knowledge, infrastructure and demand needed to capture emerging opportunities. Still, transitioning to a young-growth timber program is dependent on many factors outside the Forest Service's control, including timber markets, industry changes, uncertainty in future supply, and litigation among others. Yet it is important to consider the different factors that could influence the duration and trajectory of switching to young-growth, such as changes in policy, the role of state and private timber lands and public-private partnerships. Given the high cost of operating in Alaska, it is important that this transition be planned in a way that allows wood processors a maximum of options, including current limited export options provided by the Limited Export Policy.

[17] Duncan, Sally, based on science by Eini Lowell, Glenn Christensen, and Jim Stevens. *Facing the Challenge of the Young, the Small, and the Dead: Alaska's New Frontier*. USDA Forest Service Pacific Northwest Research Station Science Findings, Issue 30, Dec. 2000, *available at* http://www.fs.fed.us/pnw/sciencef/scifind30.pdf.

Conclusion

It is commonly claimed that allowing limited log exports reduces the number of local jobs, but this has not proven true for the Tongass National Forest. In practice, the current Limited Export Policy has allowed a steady supply of volume from the Tongass National Forest which supports the local industry. Eliminating the Limited Export Policy under current market conditions would result in a significant reduction in volume, value, and jobs. The purpose of all Forest Service export policy changes have focused on the development and continued existence of adequate wood processing capacity needed to meet national, regional, and forest management goals and objectives. The ultimate purpose of allowing export on a limited basis is to help achieve forest plan goals and objectives for which the effects have been analyzed during development of the Forest Plan as amended. The key goal is to accelerate the transition to young-growth while seeking to provide a supply of timber that meets planning cycle and annual demand from the Tongass. The Limited Export Policy is even more vital to sustain the local industry during the transition to young-growth by allowing timber purchasers to export lower value logs while establishing a market for young-growth sawn products.

APPENDIX I
DEIS COMMENTS AND RESPONSES

COMMENT SUMMARY and RESPONSES
2015 TONGASS AMENDMENT DRAFT EIS

June 2016

Appendix I

DEIS Comments and Responses

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Attachment A **Letters from Agencies, Elected Officials, and Tribal Governments**

Appendix H

Comments and Responses

A. Introduction

The Tongass Land and Resource Management Plan Amendment Draft Environmental Impact Statement (EIS) and the Draft Proposed Land and Resource Management Plan were completed and mailed out in November 2015 to organizations and individuals on the Tongass National Forest's mailing list. On November 20, 2015, an NOA of the DEIS was published in the Federal Register (80 FR 72719), which started the 90-day public comment period. The document and supporting documents were also posted on the project web site (http://www.fs.usda.gov/goto/R10/Tongass/PlanAmend).

This appendix presents a summary of the comments received during the public comment period and provides the Forest Service's responses to these comments. In addition, Attachment A provides copies of the letters received from government agencies, elected officials, and tribal governments.

Public Meetings

In January and February 2015, public open house were held in Juneau, Sitka, and Ketchikan to engage the public in the planning process and share information about the progress being made on the Proposed Forest Plan and DEIS. All of the open house materials were posted on the Forest Plan Amendment Web site.

In January and February 2016, the Forest Service hosted nine public open house meetings, each followed by a subsistence hearing. These public open house meetings were held in the following Southeast Alaska communities: Klawock, Ketchikan, Wrangell, Petersburg, Juneau, Sitka, Hoonah, Yakutat, and Kake. Participants had the opportunity to review the contents of the Proposed Forest Plan, including the five alternatives analyzed in the DEIS. Forest Service staff provided an overview, listened to public concerns, and was available to answer questions. The public was informed on how to submit comments, invited to submit written comments during the open house, and informed on the date comments must be received by. Although an ANILCA Section 810 evaluation and determination was not required for approval of a Forest Plan amendment (see Subsistence section in Chapter 3 of FEIS), subsistence hearings were held after each open house meeting, which gave the public an opportunity to provide oral testimony regarding concerns about the Proposed Forest Plan Amendment on subsistence uses.

Public Input

The Forest Service received more than 165,000 comments during the public comment period. These pieces of input, referred to here as "comment documents," were provided in a number of different forms, including email, letter, fax, public testimony, and written comments. As part of the initial comment evaluation process, comment documents were initially divided into unique comment documents and form comment documents. Less than 1 percent of these documents received were classified as unique comment documents; with the rest being either form letters or non-substantive comments. Comments are considered substantive when they are within the scope of the proposal, are specific to the proposal, have a direct relationship to the proposal, and include supporting reasons for the responsible official to consider.

Many of the comments received by the Forest Service during the public comment period were determined to be form letters. A document was considered to be a form letter when copies of the same or substantially similar document (letter, email, comment form, etc.) were submitted by five or more people. Form letters are typically generated by special interest organizations that encourage their members to

write letters, and provide a written template for them to use. In some cases members are encouraged to add their own personal message to the template.

A total of 16 different form letter templates were identified. These templates are summarized below:

- Form letter template one requested that the Tongass "take bold action to protect the Tongass" and stated that "15 years for a transition is far was too long" to protect the sensitive resources found on the Tongass. It went on to say that the range of alternatives considered in the EIS was inadequate, and requested that the logging of old-growth be ended immediately.
- Form letter template two stated that "Alaskan's want a Tongass Forest plan that works for all of us, not just the timber industry", and that the Forest Service should shift their priorities to "meet the needs of the local small mills who are adding a tremendous amount of value to their produces". The form letter went on to ask the Forest Service to enhance the salmon and tourism sectors of the economy.
- Form letter template three addressed the role the Tongass plays in global climate change, and stated that "old-growth is much more valuable for carbon storage than timber production".
- Form letter template four urged the Forest Service to ensure that the amendments to the Forest Plan protect high value fish watersheds and make the production of wild salmon, trout, and steelhead their highest management priority.
- Form letter template five requested that the clearcutting of old-growth be ended in 5 years instead of 15 years. It further stated that the 17 million that is annually generated by timber in the region is less than 1 percent of the combined 2 billion generated by fishing and tourism in the region, and that the Forest Service should focus on these resources instead of timber.
- Form letter template six stated that the draft plan is inconsistent with the current U.S. policies regarding climate change, and that the forest plan should focus on establishing an economic future for southeast Alaska that is based on restoration, recreation, fishing, and tourism instead of timber.
- Form letter template seven requested that the practice of "industrial-scale clearcutting" of old-growth be stopped as soon as possible.
- Form letter template eight requested that the Tongass transition away from harvesting old-growth sooner than 10 years, and that the Forest Service should "stop preparing more old-growth timber sales like the massive and highly ill-advised Big Thorne Project".
- Form letter template nine requested that all proposed harvesting of old-growth be removed from the plan. The form letter also requested that the Tongass "stop cutting its budget for programs that support education, tourism, recreation, and public outreach".
- Form letter template ten requested that clearcutting be ended in 3 years not 15. It further requested that the Tongass manage and protect the forests instead of "selling them at wholesale rates to Asia".
- Form letter template eleven stated that because the Prince of Wales wolves are no longer protected under the ESA, protecting the old-growth trees on the Tongass, which the wolves depend on, is critically important.
- Form letter template twelve requested that the Tongass end all "large-scale clearcutting of old growth as soon as possible", and that the old-growth trees are far more valuable standing than they are cut down. Reasons to support this claim is that these trees provide habitat for wildlife, have benefits to carbon sequestration, have cultural values, and provide opportunities for tourism.

- Form letter template thirteen requested that the Tongass adopt Alternative 5; remove salmon producing watersheds, priority conservation areas, and roadless areas from the timber pool; and make Fish Bay and old-growth reserve.
- Form letter template fourteen requested that forests in general be preserved globally to enhance carbon sequestration and protect wildlife habitats.
- Form letter template fifteen requested that instead of clearcutting the maturing forests found on the Tongass to "prop up a timber industry in economic transition", the Forest Service should focus on the restoration of forests and watersheds.
- Form letter template sixteen requested that the Forest Service "not pass the Tongass Land Management Plan", and stated that there is more than enough renewable timber in the U.S.

The large number of documents reflects the importance of the Tongass National Forest at a national level. It also reflects the membership and geographic reach of the organizations that prepared the original written templates.

The total number of form comment documents received in response to this Draft EIS (over 165,000) is more than double the comments received on the 2008 Forest Plan DEIS (82,407).

Comment Document Evaluation

Each comment document was assigned a unique identifier (number) upon receipt and entered into a database. Documents were numbered in the order received by the comment management team. Summary demographic information for each response was entered into a database, including the name and address of the comment author (when provided), the type of comment author (individual, government agency, environmental organization, etc.), and the method of transmittal (online comment form, email, U.S. Mail, public hearing testimony, hard copy comment form).

Members of the comment management team read each comment document and identified the comments within each document. Comments were identified for one copy of each form comment document. Comments were defined for the purposes of this initial identification phase as a coherent segment of text that stood alone as a suggestion, idea, request, or critique. Comments were delineated on a hard copy of the comment document and each comment was assigned a number. The comment number was entered into a database and assigned to a coding category. Up to three key words or terms that further characterized the comment, along with additional notes, were entered in separate fields in the database, as appropriate. The initial coding categories corresponded for the most part with the resource areas addressed in the Draft EIS. A copy of each coded comment document was scanned and saved as a unique PDF file.

Comment Summaries and Responses

The database allowed the comments to be sorted by coding category and key words. Resource specialists and members of the Forest Service interdisciplinary team reviewed all the comments and consolidated the individual comments into logical comment summaries, developed responses to the comment summary, and revised the analysis or text in the Final EIS, as appropriate. The comment summaries and responses are presented in Section B of this appendix. Some comment summaries represent a concern raised once; others represent a concern, opinion, or preference that was repeated in a number of different comments.

Many of the comments consisted of statements of opinion or preference, and while they were considered, they did not require a written response. For substantive comments that require a response, comment summaries and responses are presented in Section B for a number of these types of comments, primarily to provide information to the public or clarify popular misconceptions. In some cases, comments prompted the Forest Service to review additional references that were submitted and some of these have been included in the EIS where they improved the analysis or discussion.

Appendix I

In accordance with 40 Code of Federal Regulations (CFR) 1503.4, the Forest Service generally considered responding in five basic ways to the substantive public comments identified in the following sections.

Modifying alternatives.

Developing and analyzing alternatives not given serious consideration in the Draft EIS.

Supplementing, improving, or modifying the analysis that the Draft EIS documented.

Making factual corrections.

Explaining why the comments do not need further Forest Service response.

Review of the public comments resulted in Alternative 5 being modified between the Draft and Final EIS to add a 100-foot no harvest buffer around anadromous lakes. Additionally, some wording that was deleted in the Proposed Forest Plan was restored (See Chapter 1, *Changes between Proposed Forest Plan and Forest Plan*.) After substantial consideration, it was decided that the range of alternatives was sufficient. The results of the public involvement and comment process did, however, lead to a number of improvements, clarifications, and updates between the Draft and Final EIS. These changes are identified where applicable in the following section (Section B).

The following section presents the comments and responses developed by the resource specialists and Forest Service managers that comprise the Interdisciplinary Team for this project. Copies of the comment documents received during the public comment period from government agencies, elected officials, and tribal governments are presented in Attachment A. All of the responses received are available for review in the project planning record.

B. Comments and Responses
General Comments (GEN)

COMMENT

GEN-1: The DEIS project planning record was incomplete. Scoping comments were missing and were not considered or responded to during the development of the DEIS. (NGO2-101)

RESPONSE

The planning record includes documents that support analytical conclusions made and alternatives considered throughout the planning process. It also includes all comments received during opportunities for public participation provided during the planning process (e.g., scoping, DEIS, and objections). The planning record also tiers to and incorporates by reference records from the 1997 Forest Plan Revision, 2003 SEIS, and the 2008 Forest Plan amendment. All timely comments, including any attached references or exhibits, have been considered and are included as part of the planning record for this Tongass Forest Plan amendment process.

The May 27, 2014 Notice of Intent (NOI) (79 FR 30074) included instructions in the "Addresses" section about how to submit written comments. All comments, including any attached references and exhibits that were submitted during the scoping comment period (May 28 – June 26, 2014) were included in the USDA Forest Service Comment Analysis and Response Application (CARA) database and were considered by the interdisciplinary team (IDT) during the scoping process. The CARA database is used to collect all letters and comments for a particular project in an easily accessible and searchable centralized repository regardless of how they were received. If written comments were submitted via U.S. mail or facsimile, the Forest Service scanned these documents and uploaded them into the CARA database.

The process of scoping is an integral part of environmental analysis, and provides an "early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action." (40 CFR 1501.7) The Forest Service Handbook (FSH 1909.15, Ch. 10, sec. 11) also provides guidance for conducting scoping to include refining the proposed action, determining the responsible official and lead and cooperating agencies, identifying preliminary issues, and identifying interested and affected persons. The results of scoping are used to clarify public involvement methods, refine issues, select an interdisciplinary team (IDT), establish analysis criteria, and explore possible alternatives and their probable environmental effects.

In July and August 2014, the IDT conducted a content analysis on the scoping comments received, and included this analysis (excel spreadsheet) as record 769_02_000017 (planning record index # 817) in the planning record. The planning record also included record 769_02_000024 (planning record index # 908), which was a link to the CARA database where the public could access all scoping comments. This link includes both scoping comments and DEIS comments.

The FEIS planning record has been updated to include all comments (in .pdf) received during a formal comment period to include scoping and DEIS comments. Subsistence testimony provided during the subsistence hearings for the DEIS was transcribed and are also included in the planning record.

COMMENT

GEN-2: The Forest Service should add information from Secretary's Memorandum regarding the retention of existing industry and the need for old-growth timber until the transition is complete.

RESPONSE

Text was added to Chapter 1, Introduction, to clarify. Further, the Need statement in Chapter 1 makes it clear that the transition is intended to be implemented in a manner that preserves a viable timber industry. Chapter 2, Alternatives Considered in Detail, discloses that all alternatives were designed to correspond with current demand projections with old growth making up a decreasing percentage of the total. Old-

growth volume would continue to decrease until it reaches about 5 MMBF per year and it would remain at that level, to support limited small timber operators.

The Secretary's Memorandum 1044-009 is included in the planning record, and has been made available on the Tongass Plan Amendment website http://www.fs.usda.gov/goto/R10/Tongass/PlanAmend

COMMENT

GEN-3: The effects of a larger harvest on the environment, commercial fishing, and tourism are unsupported by the record

RESPONSE

You are correct that a larger harvest does not always mean greater environmental effects. It depends on the type of harvest, the location of harvest, and whether old growth or young growth is being harvested, among other factors. These are the types of questions that are the primary subjects analyzed in the FEIS. The FEIS record supports the document. Thank you for your comment.

COMMENT

GEN-4: An Executive Summary should be included in the FEIS.

RESPONSE

A plan amendment summary was provided as part of the proposed Forest Plan and Draft Environmental Impact Statement (DEIS) for the Tongass National Forest. This summary was made available on the CD-ROM, on the Tongass Plan Amendment website http://www.fs.usda.gov/goto/R10/Tongass/PlanAmend, and was made available at the public open house meetings / subsistence hearings in January 2016. A summary will also be included as part of the Final Environmental Impact Statement (FEIS) package.

COMMENT

GEN-5: Concerns were expressed that the amendment process is being rushed to comply with a directive from the Secretary of Agriculture and is unlikely to produce a viable, sustainable transition plan.

RESPONSE

See response to P&N-3 and P&N-4

If a need for change is determined by the responsible official an amendment may be considered. Plan amendments are intended to be an adaptive management tool to keep plans current, effective, and relevant between required plan revisions (every 15 years) (see FSH 1909.12 Chapter 20, Section 21.3).

COMMENT

GEN-6. The Forest Plan should provide sustainable management, maintain a viable timber industry with local processing, and encourage renewable energy development.

RESPONSE

We appreciate this input. The range of alternatives analyzed in detail support these and other goals to varying degrees.

COMMENT

GEN-6: Protect Tongass old growth and/or stop clearcutting.

The Forest Service should protect the Tongass and stop industrial-scale logging, clearcutting, and high-grading old-growth, or stop resource extraction altogether. The Forest should be protected for its many values (e.g. habitat, streams, fisheries, species diversity, runoff and flood control, recreation, hunting and subsistence, commerce, its role in addressing air quality and climate change, the potential for

undiscovered value, and providing human health benefits) and to preserve the forest for future generations. Some recommended the entire forest be set aside as a national park or wilderness.

RESPONSE

See responses to TIM-19, ALT-3, and ALT-11.

COMMENT

GEN-7: The Forest Service did not do enough public notification for this project and information was hard to find.

RESPONSE

Public notification and opportunities to participate and comment are described in Chapter 1.

COMMENT

GEN-8: Suggestions to recommend Wilderness or other special designation for specific areas including all of the areas proposed for protection by Trout Unlimited, Audubon Alaska, Southeast Alaska Conservation Council, and Tenakee Inlet by the Chichagof Conservation Council, among other areas.

RESPONSE

Wilderness designations are outside of the scope of this plan amendment, as well as outside of the authority of the Forest Service.

Purpose and Need (P&N)

COMMENT

P&N-1: The purpose and need section ignores some of the aspects outlined in the Secretary's Memo, such as transitioning forest management on the Tongass to be more ecologically, socially, and economically sustainable. Commenters believe that the Secretary's intent to transition away from old-growth harvesting in 10 to 15 years "so that after this timeframe the vast majority of timber sales on the forest will be from second-growth forests," was meant to end old-growth logging on the Tongass. Commenters are concerned that the DEIS preferred alternative (Alternative 5) increases rates of old-growth logging higher than the recent 10-year average for at least another 16 years.

RESPONSE

The Purpose and Need statement responds to the Secretary's Memorandum 1044-009 that directs a "transition over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth." The Secretary did not envision an end to old-growth logging, and this is made clear in the Memo under 1. PURPOSE AND BACKGROUND where it reads as follows:

> "To ensure a smooth transition, the Forest Service will continue to offer a supply of old growth timber while increasing the supply of young growth to provide industry in Alaska the opportunity to develop new markets, learn new skills, and acquire new equipment. The continuation of limited sales of old growth timber is essential to maintain the existing industry until young growth can efficiently be processed. The Forest Service will also continue the Tongass National Forest's micro-sale program and the old growth small sale program that targets niche markets, while developing a new integrated program of work focused on young growth, ecological restoration, and forest stewardship that protects and restores the Forest's extraordinary fish and wildlife habitat."

The 2008 Forest Plan "planned" for a longer transition to young-growth management, and the ROD made it clear that there was an "expected increase in young-growth management over the next few planning cycles." (USDA 2008a, p. 10). The Secretary's memo directs the Tongass National Forest to "expedite" this transition.

Basic tools used in the development of the alternatives include recent draft timber demand projections in Daniels et al. (USDA 2015). Alternatives 1 through 5 were designed to correspond with current demand projections and produce a projected timber sale quantity (PTSQ) of about 46 MMBF per year during the next 15 years, with old growth making up a decreasing percentage of the total. Old-growth volume would continue to decrease until it reaches about 5 MMBF per year and it would remain at that level, to support limited small timber operators. As more young growth becomes economic to harvest, the PTSQ would be allowed to increase. In no case, would the harvest level be allowed to exceed the sustained yield limit (SYL).

Also, see the recently finalized Tongass National Forest timber demand: projections for 2015 to 2030 (Daniels et al 2016), available online at: http://www.treesearch.fs.fed.us/pubs/50909

COMMENT

P&N-2: Changes to the Forest Plan's direction for transportation does not fulfill the Purpose and Need. The Purpose and Need section of the DEIS simply states that "[c]hanges to the Forest Plan are needed to make the development of renewable energy resources more permissible, including considering access and utility corridors to stimulate economic development in Southeast Alaska communities." The new Transportation Systems Corridor direction in the Proposed Forest Plan is not related to or limited to renewable energy projects.

RESPONSE

The responsible official has the discretion to determine whether and how to amend the plan (36 CFR 219.13(a)). Based on comments received on the Five-Year Review of the Forest Plan, completed in 2013, the responsible official determined that there was a need "to make the development of renewable energy resources more permissible, including considering access and utility corridors to stimulate economic development in Southeast Alaska communities, and provide low carbon energy alternatives, thereby displacing the use of fossil fuel."

The responsible official has the authority to remove the existing Transportation and Utility System (TUS) Land Use Designation (LUD) overlay under the action alternatives in the DEIS under 36 CFR 219.13(a). The last sentence of 36 CFR 219.13(a) states that: "Except as provided by paragraph (c) of this section, a plan amendment is required to add, modify, or remove one or more plan components, or to change how or where one or more plan components apply to all or part of the plan area (including management areas or geographic areas)." (Emphasis added). The Department added the phrase "including management areas or geographic areas" to the final planning rule to clarify that an amendment is required for any change in how or whether plan components apply to those areas (77 FR 21238). That addition to the final rule and the provision that an amendment is necessary to remove plan components shows that the proposed amendment is legitimate. An amendment may remove all the plan components within a LUD and remove the LUD itself.

To meet the purpose and need, new direction (i.e., plan components and management approaches) was developed for renewable energy. To ensure future project decision-making was consistent with the amended plan, the responsible official decided to remove the TUS LUD and add to and modify the TUS LUD management prescription as plan components (see 36 CFR 219.7 (e)) in the amended plan. This new direction for renewable energy and transportation systems corridors is applied to the remaining 18 LUDs.

The intent of the Forest Plan direction for transportation systems corridors is not to change the process the Forest Service will go through when developing future transportation systems. The purpose of the plan direction for transportation systems corridors is the same as the 2008 TUS LUD management prescription; to facilitate the availability of National Forest System land for the development of existing and future transportation systems such as those identified by the State of Alaska in the current version of the Southeast Alaska Transportation Plan (SATP) and applicable laws. (See Forest Plan Chapter 5.) The applicable transportation systems corridors direction in Chapter 5 is included for each LUD in Chapter 3 in a table that cross-references, by category, the plan content, found in Chapter 5.

COMMENT

P&N-3: The Department of Agriculture's policy to expedite a transition away from old-growth timber harvesting and towards a forest industry that utilizes second growth – or young growth – forests as expressed in the Secretary's Memorandum (1044-009), is premature and would not restore a viable timber supply in Southeast Alaska.

RESPONSE

Under the direction of Thomas Vilsack, Secretary of Agriculture, the U.S. Department of Agriculture (USDA) administers the U.S. Forest Service. The Secretary of Agriculture is a member of the president's cabinet who takes the lead with USDA for the development of implementing policy on a variety of programs and services. The Secretary's Memorandum (1044-009) *Addressing Sustainable Forestry in Southeast Alaska* was signed on July 2, 2013 and sets forth USDA policy for the Forest Service on the Tongass National Forest. Secretary Vilsack was quoted in a USDA Forest Service news release on July 2, 2013:

> "Today, I am outlining a series of actions by USDA and the Forest Service that will protect the old-growth forests of the Tongass while preserving forest jobs in southeast Alaska… I am asking the Forest Service to immediately begin planning for the transition to harvesting second growth timber while reducing old-growth harvesting over time."

The actions outlined in the Secretary's Memo that are carried forward in the amended plan are focused on conserving old-growth temperate rainforests of the Tongass, while ensuring a transition to second-growth forests so that current forest industry can continue to provide jobs and opportunities in Southeast Alaska. A transition timeframe of 10 to 15 years is intended to conserve old growth forests while allowing the forest industry time to adapt to this shift away from old-growth to young-growth forest management.

Flexibility, like that provided by Congress in the National Defense Authorization Act for Fiscal Year 2015 (Public Law 113-291, December 19, 2014, 128 Stat. 3729, section 3720(e)(4)) allows the harvest of trees prior to the culmination of mean annual increment of growth on lands identified as suitable for timber production to facilitate the transition from commercial timber harvest of old growth stands.

Alternatives 1 through 5 in the EIS were designed to correspond with current demand projections and produce a projected timber sale quantity (PTSQ) of about 46 MMBF per year during the next 15 years, with old growth making up a decreasing percentage of the total. As more young growth becomes economic to harvest, the PTSQ would be allowed to increase. In no case, would the harvest level be allowed to exceed the sustained yield limit (SYL).

See response to P&N-9.

COMMENT

P&N-4: The young-growth inventory and associated modeling used by the agency for the amended plan is not reliable to support the purpose and need.

RESPONSE

The 2008 Forest Plan Record of Decision (ROD) highlights the uncertainty about short- and long-term social, economic, and environmental risks and preparing to adjust promptly if conditions change. The responsible official noted in the 2008 ROD that there was an "…expected increase in young-growth management over the next few planning cycles; and the increasing public interest in this conversion, which will ultimately reduce the need for old-growth timber resources…" (USDA 2008a, P. 10).

With this in mind, the agency has made a concerted effort in the last decade to increase knowledge and information of the young-growth resource that is being used as the forest moves toward a forest management program that is focused on young-growth management. The agency has expended considerable effort and funds to acquire data and expertise to prepare for and define realistic expectations for a transition to young-growth forest management. In 2009, the Tongass acquired the Forest Projection and Planning System (FPS) software to serve as the Forest's primary growth and yield model, which allows us to store, track and grow our stand inventory. This model is spatially explicit and is robust enough to handle forest wide analyses. This model has also allowed us to apply stand information that was collected in one stand to similar stands. As more data is collected on the ground, this model will become a more robust resource management tool.

The Tongass is an annual contributor to the Forest Biometrics Research Institute (FBRI) which is a non-profit public corporation dedicated to research, development, service and education organization in the field of forest inventory, forest growth and forest planning for sustainable and scientific forest management. This ensures that the regional species library used in the FPS growth and yield library remains certified and updated in a manner that is repeatable and scientifically based. In order to provide updated information to FBRI, the Tongass has funded the Pacific Northwest Research Station's (PNW) Juneau Forestry Sciences Laboratory to remeasure their extensive network of permanent growth and yield plots. The permanent plots of the Cooperative Stand Density Study that were established 40 years ago provide long-term growth response of thinned and unthinned even-aged stands at over 50 locations throughout southeast Alaska. PNW is also monitoring permanent plots established in the 1920s. The long-term growth and yield record from the PNW permanent plots was used to create the southeast Alaskan variant of FPS in 2005 and more recently collected data were used in the 2015 recalibration of the Southeast Alaska information.

Some of the efforts that have been undertaken since 2005, more information is included in FEIS and the planning record:

- 2005 and 2011 - Two large scale young growth inventories of the Forest's oldest young-growth stands.

1. 2009 - FPS growth and yield model software obtained to serve as the Forest's primary growth and yield model to store, track and grow our stand inventory forward in time.
2. 2010 - ongoing work with FBRI to establish the Tongass Inventory Database within the FPS growth and yield model, FBRI developed a forest wide site productivity based upon a stratified distribution of Forest Inventory Analysis (FIA) site measurements across the Forest.
3. 2014 - Tongass, in conjunction with Sealaska, signed a cost share agreement with the Working Forest Group to hire an independent consultant to evaluate the FPS model who found the overall volume projections are within an acceptable range.
4. 2014 – a review of the young-growth forest management and conditions in GIS was conducted.
5. 2015 - "Woodstock", a forest management modeling system was used for long term strategic planning in order to define the long-term, non-declining, sustained yield from our land base.
6. 2016 – Challenge cost share agreement with the State of Alaska to conduct the currently ongoing young growth inventory. See response to ECON-6.

COMMENT

P&N-5: The need expressed in the "purpose and need" section of the EIS is not warranted. Fuel prices have dropped precipitously over the last year or so, and there is no factual basis to support a pending climate change impact on the quality of life in the region.

RESPONSE

See responses to P&N-1 and P&N-3.

The Forest Service identified the need to make the development of renewable energy resources more permissible…thereby displacing the use of fossil fuel" is a valid one. A fall 2015 science update entitled *Energy Anxiety*, published by the USDA Forest Service Pacific Northwest Research Station states, "[r]ecently, crude oil prices have dropped considerably, but it is unclear what percentage of these cost savings will find its way to remote communities. The statewide average annual energy costs per household are frequently more than twice the national average. The price of heating oil, diesel fuel, and gasoline weighs heavily on Alaskans, particularly for isolated and economically struggling villages." (USDA 2015k) The Climate and Air section in Chapter 3 of the FEIS includes a section on climate change, and the effects of climate change are disclosed.

COMMENT

P&N-6: The purpose and need statement is arbitrarily narrow and results in a range of alternatives that limit the transition timeframe and timber volume. Some concerns expressed that this results in a transition that is too slow and focused on timber industry needs, while other express the opposite, that this results in a transition that is too fast with not enough timber volume.

RESPONSE

See response to P&N-3.

The Purpose and Need was based on a need for change. Chapter 1 of the FEIS includes a section entitled, *Factors That Led to the Need for Change*, which provides the context for the factors that led to a need for change.

The responsible official has the discretion to determine whether and how to amend the plan (36 CFR 219.13(a)) and the Forest Service has flexibility in defining the purpose and need for action so long as it is not arbitrarily narrow. The Purpose and Need responds partly to the Secretary's Memorandum that directs a "transition over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth." Secretary Vilsack's memorandum also guides that the transition should be implemented in a manner that preserves a viable timber industry that provides jobs and opportunities for Southeast Alaska residents. The Purpose and Need also responds to information generated during the Five-Year Review of the Forest Plan in 2013. The scope of the plan amendment is narrow because it is an amendment; not a revision, and the range of alternatives in the DEIS concentrate solely on the need for change as documented in the 5/27/14 NOI and the refined Purpose and Need statement in the DEIS.

The Secretary's Memo stated that "[the 10-15 year] timeframe will conserve old growth forests while allowing the forest industry time to adapt." The Secretary did not envision an end to old-growth logging, and this is made clear where the Memo reads, "To ensure a smooth transition, the Forest Service will continue to offer a supply of old growth timber while increasing the supply of young growth to provide industry in Alaska the opportunity to develop new markets, learn new skills, and acquire new equipment. The continuation of limited sales of old growth timber is essential to maintain the existing industry until young growth can efficiently be processed." In terms of "preserving a viable timber industry that provides jobs and opportunities for Southeast Alaska residents," an effort to document current timber industry trends and to project future timber demand was undertaken. The Tongass National Forest requested the Pacific Northwest Research Station to update long-term Tongass National Forest timber demand projections, 2015 – 2030. During the past 25 years, the U.S. Forest Service, Pacific Northwest (PNW) Research Station has published several studies in support of Tongass National Forest land management planning that estimate derived demand for Southeast Alaska timber including Brooks and Haynes (1990, 1994, 1997), Brackley et al. (2006a), and Daniels et al. (2016). Daniels et al. (2016) is the fifth such analysis performed since 1990 to assist forest planners in meeting statutory requirements for estimating planning cycle demand for timber from the Tongass National Forest. The PNW Research Station's timber demand projections are based on solid economic theory, peer-reviewed methodology, and rigorous and objective analysis.

The intent of the Tongass Timber Reform Act (TTRA) was to maintain a timber industry in southeast Alaska while providing more resource protection, particularly forested buffers to fish-bearing streams in support of economic diversity. Providing old-growth 'bridge' timber during the transition is designed to fulfill the 'seek to meet' intent of TTRA. This will give industry the needed time to retool their mills or new industry to start up. Determining what demand estimates mean for timber sales offered from the Tongass National Forest involves taking the results from Daniels et al. (2015, 2016) and using them as input to a supply calculation that seeks to meet annual market demand from the forest. The derived demand projections developed by Daniels et al. were used to estimate the market demand for the current Tongass National Forest planning cycle, which is 46 MMBF per year.

Alternatives were modeled to ensure that land allocations and output schedules for alternatives are realistic and meet Forest Plan direction in a cost-efficient manner. Results from the modeling process are only approximations of what to expect when any given alternative is implemented. The main purpose of modeling is to aid planners in estimating likely future consequences of management prescriptions. A choice between alternatives can be made even though the model may lack precision in describing specific attributes of a given alternative.

All action alternatives in the DEIS were developed to address the significant issues and meet the Purpose and Need. It is not always possible to provide all resource use opportunities in the amounts desired by everyone. The National Forest Management Act (NFMA) mandates the Forest Service to provide for multiple use and the sustained yield of the products and services obtained from the Forest. In an effort to help the Forest Service balance multiple use goals on the Tongass and continue to seek input from and work with stakeholders in the region towards this transition, the USDA established a Federal Advisory Committee under the Federal Advisory Committee Act to advise the Secretary and Chief on transitioning the Tongass to young-growth forest management. The committee, known as the Tongass Advisory

Committee (TAC), consisted of members from the timber industry, conservation community, Native interests, state and local governments and other interests.

In January 2015, the TAC recommended the Purpose and Need should consider an alternative that "[maximizes] the opportunities for social and economic returns from other economic sectors that depend on the Forest." The Under Secretary responded to the TAC in writing in May 2015 stating the following:

> "Let me be clear that USDA's top priority with the Transition Framework is maintaining resilient communities in Southeast Alaska… Including the language in the Purpose and Need as you suggest would broaden the scope of the Plan Amendment in a way that would require a corrected NOI, and an additional public comment period prior to the Draft Environmental Impact Statement (DEIS). We therefore propose recognizing the values that your suggested language addresses, without changing the purpose and need under NEPA. Meeting your interests this way, the agency could recognize the range of social and economic values supported by the Tongass, without needing to re-issue the NOI for a new round of public comment."

The TAC recommendations were carried forward in the amended plan as Alternative 5 (preferred alternative), and this will enable the Forest to move out of old growth as quickly as possible and accelerate the transition while sustaining an economically viable timber industry. The agency has the authority to amend the forest plan, which is one step in addressing sustainable forestry in Southeast Alaska. Additional steps in the TAC's detailed implementation recommendations provide guidance on elements for success in implementing the transition, and identify opportunities by which the agency, stakeholders, and greater community will share ownership of the transition strategy and embrace its successful implementation. The work done by the TAC offers the possibility of a regionally focused, collaborative path toward an innovative opportunity for a viable young-growth timber industry while honoring the suite of economic, ecological, social, and cultural values inherent in the Forest. The TAC provided detailed recommendations for targeted investment, financial assistance, and financing mechanisms for stand inventory, research, infrastructure, and retooling. These investments are intended to help communities and businesses successfully transition to, and thrive within, a new young-growth economy.

Plan amendments are intended to be an adaptive management tool to keep plans current, effective, and relevant between required plan revisions (every 15 years). Amendments help Responsible Officials adapt an existing plan to new information and changed conditions. Maintaining plans through amendment also may reduce the workload for subsequent plan revisions. Amendments may be broad or narrow in scope, depending on the need to change the plan. An assessment for a plan amendment is not required, but may be developed at the discretion of the Responsible Official (see FSH 1909.12, chapter 10, section 15). Whether an amendment is proposed in response to changing conditions or in relation to a specific project, the Responsible Official should keep the scope and scale of the process, including public participation, commensurate with the scope of the plan amendment (CFR 219.13(b)(2)).

The Forest Service has the authority to amend the forest plan, which is one step in addressing sustainable forestry in Southeast Alaska. Additional steps in the TAC's detailed implementation recommendations provide guidance on elements for success in implementing the transition, and identify opportunities by which the agency, stakeholders, and greater community will share ownership of the transition strategy and embrace its successful implementation. The work done by the TAC offers the possibility of a regionally focused, collaborative path toward an innovative opportunity for a viable young-growth timber industry while honoring the suite of economic, ecological, social, and cultural values inherent in the Forest. The TAC provided detailed recommendations for targeted investment, financial assistance, and financing mechanisms for stand inventory, research, infrastructure, and retooling. These investments are intended to help communities and businesses successfully transition to, and thrive within, a new young-growth economy.

A recent report by Government Accountability Office (http://gao.gov/products/GAO-16-456) outlines additional steps taken or planned by the Forest Service, including comparing potential market prices for young-growth timber or products to the cost to harvest, transport, and process the timber; refining of young-growth timber data; lengthening the duration of small sale contracts to provide small-mill owners

with flexibility; and expanding collaborative projects to support job creation through sustainable forest management and improve predictability of timber supply.

COMMENT

P&N-7: The Forest Service has abandoned prior commitments to Southeast Alaska communities, citing the July 2013 memo, signed by USDA Secretary Vilsack, to expedite the transition from old-growth to young-growth timber harvest while supporting a viable timber industry, retaining industry expertise and infrastructure, and ensuring young-growth harvest in tandem with continued old-growth harvest to maintain the industry during the transition.

RESPONSE

Chapter 1 of the FEIS includes a section entitled, *Factors That Led to the Need for Change*, which provides the context for the factors that led to a need for change. One of the factors discussed in this section is about collaboration and the important relationships that were established that laid the groundwork for the "Transition Framework."

In a May 24, 2014 letter to the Tongass Futures Roundtable, signed by Alaska Regional Forester Beth Pendleton, the agency effectively announced the "Transition Framework". The letter indicated the Agency's belief that it is possible to "provide economic opportunity and jobs to local residents and to sustain a viable timber industry while at the same time transitioning from timber harvesting in roadless areas and old-growth forests to long-term stewardship contracts and young-growth management." (USDA 2014). The letter further outlines an approach to collecting input from Southeast residents and communities, a priority to support regional economic diversification, and a new vision for forest management. Since this time, the agency has invested significant resources in conducting public outreach, facilitating economic development, and amending the forest plan. As stated in the original letter announcing the "Transition Framework", the agency maintained focus on the overarching goal of working with community members to create jobs in Southeast Alaska (USDA 2010).

In an effort to document current timber industry trends and to project future timber demand, the Tongass National Forest requested the U.S. Forest Service, Pacific Northwest (PNW) Research Station update long-term Tongass National Forest timber demand projections, 2015 – 2030. During the past 25 years, the Pacific Northwest Research Station has published several studies in support of Tongass National Forest land management planning that estimate derived demand for Southeast Alaska timber including Brooks and Haynes (1990, 1994, 1997), Brackley et al. (2006a), and Daniels et al. (in press). Daniels et al. (in press) is the fifth such analysis performed since 1990 to assist forest planners in meeting statutory requirements for estimating planning cycle demand for timber from the Tongass National Forest. PNW Research Station's timber demand projections are based on solid economic theory, peer-reviewed methodology, and rigorous and objective analysis.

PNW Research Station scientists made two trips to Southeast Alaska with the specific purpose of collecting information and data from public and private sector stakeholders. Multiple meetings were conducted during summer and fall 2014 with the State of Alaska Department of Natural Resources, Alaska Mental Health Trust, Sealaska Corporation, Thuja Plicata, Western Gold Cedar Mill, Good Faith Lumber, and ALCAN Forest Products. Information provided by the aforementioned, among many other sources, where considered in the development of long-term timber demand projections.

Additionally, Management Approaches in Chapter 5 for the Forest Plan state the intent to "engage stakeholders (for example, conservation interests, timber operators, permitted user groups, and other interested parties) early and often to best design projects that meet ecological, social, and economic interests. Such inclusion would surface and resolve differences, and minimize and avoid social, environmental, and natural resource conflicts. At the earliest possible time, IDTs would engage scientific and technical expertise, and knowledge of local resources to encourage creative thinking and enhance integration and coordination among jurisdictions."

COMMENT

P&N-8: The purpose and need statement is arbitrarily narrow, resulting in a range of alternatives that is not broad enough to address ecological and social and economic sustainability. Concern was expressed about the ecological and socio-economic changes that have occurred in the region since the 1997 Forest Plan was revised. The forest plan should be revised since the 2012 Planning Rule requires that "plans to be "revised at least every 15 years." (36 CFR 219.7(a))

RESPONSE

See responses to P&N-6 and P&N-7.

The purpose and need does not support a plan revision. We are making changes to:

1. Amend plan direction for timber harvesting to expedite the transition to young-growth forest management
2. Amend the plan direction to make the development of renewable energy resources more permissible, and
3. Make miscellaneous technical adjustments to the plan.

Because the 2008 plan amendment essentially completed the process of revising the Tongass Forest Plan that was initiated in 1987, the Forest Plan will not need to be revised again until 2023, unless changed conditions require it sooner. (USDA 2008a). No matter when the time starts to do a plan revision, the annual appropriations acts for the Department of the Interior, Environment, and Related Agencies have regularly permitted Forest Service land management plans to be more than 15 years old if USDA is acting in good faith to update the plans. The Chief's schedule for plan revision is available online at http://www.fs.fed.us/emc/nfma/index.htm

COMMENT

P&N-9: The purpose and need is arbitrarily narrow because it is unreasonable to focus an entire Plan Amendment on satisfying the perceived needs of two timber exporters at the expense of social, economic and ecological sustainability.

RESPONSE

See responses to P&N-1, P&N-6, P&N-7 and ALT-1.

The need for change comes from a July 2013 memo from U. S. Department of Agriculture Secretary Tom Vilsack (Secretary's Memorandum 1044-009) directing the Tongass to transition its forest management program to be more ecologically, socially, and economically sustainable, as well as information generated during the Five-Year Review of the Forest Plan in 2013.

COMMENT

P&N-10: Purpose and Need aims to support a marginal component of the regional economy instead of recreation, wildlife and fishing, which are the regional economic drivers. The Purpose and Need arbitrarily focuses on preserving a viable timber industry and fails to respond to changed conditions and circumstances in terms of multiple uses that are relevant to public land management in southeast Alaska. The amended plan does not meet the substantive requirement to provide for social, economic and ecological sustainability (36 CFR parts 219.8) and that substantial changes are needed to allow for a broader planning process.

RESPONSE

See responses to P&N-6, P&N-9, ALT-1

Chapter 1 of the FEIS includes a section entitled, *Factors That Led to the Need for Change*, which provides the context for the factors that led to a need for change. The purpose and need responds to the

specific factors identified in the Secretary's memo - primarily rapid reduction of old-growth harvest and maintenance of a viable timber industry. The purpose and need does not respond to changed conditions and circumstances in terms of other multiple uses because changes that have occurred and will occur in these areas are generally well within the range of changes anticipated by the 1997 Revision and the 2008 Amendment. The Responsible Official determines how broad or narrow the scope of the amendment will be and thereby what provisions of the Rule apply; based on the narrow scope of this amendment, the sustainability provision at 36 CFR 219.8 was not invoked.

COMMENT

P&N-11: Consolidating the modifications made to the Forest Plan since its approval does not require an early transition to young-growth harvesting.

RESPONSE

Chapter 1 of the FEIS includes a section entitled, *Factors That Led to the Need for Change*, which provides the context for the factors that led to a need for change.

It is not necessary to transition to young-growth harvesting to consolidate the modifications to the Forest Plan. However, this is a good opportunity to include the amendments made since the decision for the Forest Plan was signed in 2008, update the land status from the recent Sealaska land entitlement finalization in the Carl Levin and Howard P. 'Buck' McKeon National Defense Authorization Act for Fiscal Year 2015, and include new resource inventory and information. This is similar to what was done with the 2008 amendment when there were changes to the Land Use Designations and other updates. This keeps the Forest Plan current as described in FSH 1909.12, chapter 20, section 21.3.

Range of Alternatives (ALT)

COMMENT

ALT-1: The development of the preferred alternative (Alternative 5) focused narrowly on the sustaining or increasing jobs that facilitate the timber industry transition. Options for sustaining or increasing jobs in other industry sectors should have been considered.

RESPONSE

See responses to P&N-6, P&N-7, and P&N-9.

In a September 30, 2013 memo entitled, *Tongass Land and Resource Management Plan 5-Year Review Determination*, the responsible official acknowledged the Secretary of Agriculture's commitment to approve the establishment of an advisory committee under the Federal Advisory Committee Act (FACA) as amended (5 U.S.C, App. 2), and he proposed establishment of such committee to provide stakeholder input on the transition (USDA 2013). In an effort to assist the Forest Service in balancing multiple use goals on the Tongass and ensuring input from and work with stakeholders in the region towards this transition, the USDA established an advisory committee to provide advice and recommendations to the Secretary and Chief on transitioning the Tongass on transitioning to young growth forest management. A charter was established under FACA for the advisory committee that outlined the objectives and scope of advice sought from the committee.

The advisory committee, known as the Tongass Advisory Committee (TAC), offers a regionally focused, collaborative path toward an innovative opportunity for a viable young-growth timber industry while honoring the suite of values – economic, ecological, social, and cultural – inherent in the Forest. Their recommendations related to modifications of the forest plan were carried forward in the amendment as Alternative 5 (preferred alternative), which enables the Forest to move out of old growth as quickly as possible and accelerate the transition while sustaining an economically viable timber industry.

The agency has the authority to amend the forest plan, which is one step in addressing sustainable forestry in Southeast Alaska as outlined in the Secretary's Memo. Additional steps in the TAC's detailed implementation recommendations provide guidance on elements for success in implementing the transition, and identify opportunities by which the agency, stakeholders, and greater community will share ownership of the transition strategy and embrace its successful implementation. The work done by the TAC offers the possibility of a regionally focused, collaborative path toward an innovative opportunity for a viable young growth-timber industry while honoring the suite of economic, ecological, social, and cultural values. The TAC provides detailed recommendations for targeted investment, financial assistance, and financing mechanisms for stand inventory, research, infrastructure, and retooling. These investments are intended to help communities and businesses successfully transition to, and thrive within, a new young-growth economy.

COMMENT

ALT-2: The range of alternatives is arbitrarily narrow and a supplemental DEIS is warranted. Alternatives should have considered economic contributions of other industry sectors, such as the fishing and tourism industries that contribute to the region's most important economic sectors.

RESPONSE

See responses to P&N-4, P&N-6, P&N-7 and P&N-9.

COMMENT

ALT-3: The agency failed to fulfill its obligations under NFMA with respect to wildlife and plant populations because it did not analyze a no old-growth logging alternative in the EIS. Dismissal of the no old-growth harvest alternative was improper and no rationale was given. All Old-growth should be unsuitable for timber production and the PTSQ for old-growth should be zero.

RESPONSE

See response to PLR-2.

An alternative that immediately eliminates old-growth logging was analyzed during the 1997 Forest Plan Revision (Alternative 1). This analysis is an amendment to that revision and further consideration is not necessary. The rationale for not selecting that alternative is discussed on p. 16 in the record of decision (ROD) of the 1997 Forest Plan Revision (USDA 1997a).

In terms of meeting the purpose and need for the amended plan, an immediate end to old-growth logging would not allow industry to transition. Under the TTRA (Public Law 101-626), as amended, the Forest Service is obligated, subject to applicable law, to meet market demand annually and for the planning cycle.

COMMENT

ALT-4: The Purpose and Need did not accurately reflect the Secretary's intent to transition "no later than 10 to 15 years" and that the agency erred by eliminating from detailed analysis an alternative that proposes a five-year transition. The agency's rationale for not analyzing this proposal in detail is flawed.

RESPONSE

The Secretary's Memo stated that "[the 10-15 year] timeframe will conserve old growth forests while allowing the forest industry time to adapt." In terms of "preserving a viable timber industry that provides jobs and opportunities for Southeast Alaska residents," a report was completed by the US Forest Service Pacific Northwest (PNW) Research Station assessing derived demand for Alaska forest products. The derived demand projections developed by Daniels et al. were used to estimate the market demand for the current Tongass National Forest planning cycle, which is 46 MMBF per year. The derived demand projections developed by Daniels et al. were used to estimate the market demand for the current Tongass National Forest planning cycle, which is 46 MMBF per year. Determining what demand estimates mean for timber sales offered from the Tongass National Forest involves taking the results from Daniels et al. (2015) and using them as input to a supply calculation that seeks to meet annual market demand from the forest.

The Forest Service considered a Five-Year Transition Alternative in the DEIS and it was modeled and extensively analyzed; however, there were several reasons that this alternative did not meet the Purpose and Need and it was not carried forward for detailed analysis.

The goal of the Five-Year transition proposal was to increase young-growth volume during this 5-year period to transition out of old growth logging more rapidly. Several "sideboards" were provided as part of this proposal to include the following: 1) total volume ≤35 MMBF per year after the transition (31.5 MMBF of young growth and 3.5 MMBF of old growth); 2) harvest only in Development LUDs; 3) old-growth harvest only in Timber Sale Program Adaptive Management Strategy Phase I lands and outside of 2001 Roadless Areas; 4) young-growth harvest allowed only in Phase I lands outside of 2001 Roadless Areas; 5) no harvest in beach and estuary fringe, RMAs, or in low, medium, or high vulnerability karst; and 6) apply CMAI flexibility - stands as young as 55 years of age (producing one-log/ tree).

When modeled, this proposal showed that it would provide for a more rapid transition compared to the other alternatives, but would not allow the Forest Service sufficient time to offer enough economic old-growth and young-growth volume during the next 10 or more years to maintain viable timber industry. Rationale for not analyzing in detail is disclosed in Chapter 2 of the EIS.

COMMENT

ALT-5: The Forest Service should complete all old-growth timber sale planning and offerings within five years or sooner.

RESPONSE

The Secretary's Memo stated that "[the 10-15 year] timeframe will conserve old growth forests while allowing the forest industry time to adapt." The Secretary did not envision an end to old-growth logging, and this is made clear where the Memo reads, "To ensure a smooth transition, the Forest Service will continue to offer a supply of old growth timber while increasing the supply of young growth to provide industry in Alaska the opportunity to develop new markets, learn new skills, and acquire new equipment. The continuation of limited sales of old growth timber is essential to maintain the existing industry until young growth can efficiently be processed."

Timber sale scheduling, as with any project scheduling, needs to be flexible to accommodate changes in policy, needs, timber appraisals, and funding. Intensive inventory work has been begun to identify the next old-growth 'bridge' timber projects but is at a stage where all of these projects cannot be identified. An effort is being made to include young-growth timber offerings along with old-growth timber to facilitate the transition. In order to have a successful transition to young-growth management, industry needs time to convert or retool to manufacture smaller logs and support with old-growth timber.

The suggested estimate that all sales need to be planned and sold by 2018 is contrary to the process used to offer Forest Service timber. Sales are typically spread out over time to account for demand, market fluctuations, and availability of NEPA cleared timber. These will be sales of various sizes and would not require a 10-year contract. Old-growth is planned to be offered throughout the range of the transition years and beyond

COMMENT

ALT-6: The range of alternatives does not include restoration options that focus on restoring the forest to natural processes that preserve remaining old-growth and allow young-growth forests set aside for conservation purposes to mature naturally and eventually develop increased wildlife habitat value. Economic considerations could reallocate the old-growth timber budget toward restoration, supporting the fishing and tourism industries, as well as selective logging for high-end specialty lumber operations. The Forest Service should prioritize spending to improve wildlife habitat, restore watersheds, and address the unmet needs of tourism, recreation, and commercial and sport fishing and hunting users.

RESPONSE

The proposed amendment has a narrow scope, which is fundamentally different from a plan revision. The scope of the amendment is defined in the Purpose and Need. As such, this proposal is outside of the scope of the plan amendment. The responsible official has the discretion to determine whether and how to amend the plan (36 CFR 219.13(a)). Amending the Forest Plan responds to the July 2013 memo from the Secretary of Agriculture directing the Tongass National Forest to transition its forest management program to be more ecologically, socially, and economically sustainable. The Forest is also being responsive to comments from the Five-Year Review of the Forest Plan. All action alternatives in the DEIS were developed to address the significant issues and meet the Purpose and Need and are designed to protect and maintain natural processes. Setting aside young-growth forests for conservation purposes does not meet the Purpose and Need.

The approved (2008) forest plan, and the ongoing program of the Tongass National Forest under that plan currently includes restoration actions particularly in young-growth stands, riparian areas and stream courses. Restoration activities would occur under all alternatives.

COMMENT

ALT-7: The range of alternatives should have included eliminating even-flow harvest.

RESPONSE

Managing on a non-declining even-flow is a requirement established by the National Forest Management Act. (See Pub. L. 93-378, §13, as added Pub. L. 94-588, §11, Oct. 22, 1976, 90 Stat. 2957.) See

response to comment TIM-5. It is the goal of the Tongass to provide an even-flow of timber on a sustained-yield basis and in an economically efficient manner. The amount of timber offered each year is based on the objective of offering enough volume to meet the projected annual demand. That annual demand projection starts with installed mill capacity, and then looks to industry rate of capacity utilization under different market scenarios, the volume under contract, and a number of other factors, including anticipated harvest and the range of expected timber purchases.

An even-flow harvest scenario provides potential purchasers sufficient volume to maintain their operations, keep skilled workers and allow them to maintain/ increase their skills, ensure their employees steady employment, and allow the purchasers to secure the financial support as needed. Fluctuation in harvest already occurs with the markets, the amount of timber available and at which location due to mobilization and to some extent the weather. This is one of the reasons that 3 years of volume under contract is preferable to allow these fluctuations.

COMMENT

ALT-8: Support for Alternative 5 because it transitions away from old-growth timber harvesting and protects some of the most important salmon producing watersheds and other biologically rich areas. Some expressed that it is a workable option that still provides some old-growth to local mills, but could be modified to exclude old-growth and/or clearcutting or to transition faster. Alternative 5 also opportunities for management of young growth that is in the stem exclusion phase.

RESPONSE

Thank you for your comment. The rate of transition is based on the availability of suitable young-growth that can be harvested economically. We agree that young-growth management will enhance forage availability and achieve the desired condition of stands faster in many locations. Alternative 5 also protects roadless areas, T77 watersheds and TNC/Audubon conservation priority areas from old-growth harvest.

See response to TIM-8 and YGAT-2.

COMMENT

ALT-9: The range of alternatives does not include an environmentally preferred alternative. There are many similarities between the action alternatives and that it is difficult to characterize which alternative is the environmentally preferable.

RESPONSE

The Forest Service has provided a reasonable range of alternatives that address the significant issues in different ways and varying degrees, and the analysis that has been completed is adequate to discuss preferences among alternatives based on relevant factors to identify an environmentally preferable alternative.

The mere presence of timber harvest in young-growth or the amount of harvest does not preclude resulting benefits, such as commercial thinning in stands to encourage growth of the residual trees and promote understory. Each alternative differs in terms of suitability of lands (i.e., determination made regarding the appropriateness of various lands within a plan area for various uses or activities, based on the desired conditions applicable to those lands) and other plan components (goals; desired conditions; objectives; standards; guidelines) that provide direction and may apply forest-wide or to specific LUDs.

The alternative or alternatives that are considered to be environmentally preferable will be identified in the record of decision.

See response to comments ALT-3, ALT-6, and ALT-11.

COMMENT

ALT-10: Specific high-value suitable lands should be removed from the timber base, and managed primarily for restoration and for special management. On these lands, the Forest Service should not permit new roads, except for spur roads which extend less than one-quarter of a mile from an existing road. These areas should be identified for a microsale program designed in collaboration with local communities.

RESPONSE

See response to ALT-6 regarding restoration options in alternatives.

The lands identified as suitable for timber production were determined by using a collaborative approach either by the Tongass Advisory Committee (Alternative 5) or by the Forest Service interdisciplinary team that includes a cooperative agency, the U.S. Fish and Wildlife Service (Alternatives 2, 3 and 4).

Areas that are to be restored or enhanced are also determined through the interdisciplinary process including public involvement or collaboration.

The lands proposed for special management (identified by commenters) will be managed in accordance with Forest Plan direction with various silvicultural prescriptions considered. Extensions of roads or new roads will be the minimum amount needed to access the timber and will consider the effects to various resources as well as the length. Areas for microsales are identified by potential purchasers and will reflect their needs.

Incidentally, for the microsale program, the potential purchasers identify the dead and down trees for harvest; not the Forest Service. That way, the purchaser is identifying trees that suit the needs of their operation.

COMMENT

ALT-11: The DEIS failed to analyze a reasonable range of alternatives by unreasonably rejecting the conservation group alternative that would complete the transition within five years. This alternative was based on using the agency's authority to follow industry practice by cutting trees well before they reached CMAI, minimizing environmental impacts and maximizing reliability by avoiding sensitive areas, and enhancing economic viability by focusing on stands near existing road infrastructure and off of steep slopes. The proposal took into account research and analysis undertaken by Mater, Ltd., based on Forest Service data, which concluded sufficient volume should be available close to currently open FS roads in the Southern Tongass, in the existing suitable land base, and avoiding sensitive lands, to conclude a transition to young growth within 5 years. None of the specific reasons in the DEIS for not carrying forward this alternative for detailed analysis, or some version of it consistent with existing data and the basic request of the conservation groups, is well-founded or supported.

RESPONSE

Although the Forest Service did commit to a quick transition in 2010 the Transition Framework (May 2010), and initiated a process to transition the timber program on the Tongass National Forest to young growth management, many questions persisted about what the transition means, why we are doing it, how we plan to accomplish it, and how it fits in with other programs. In January 2013, a "Leader's Intent" document was released by the R10 Regional Forester and the Tongass Forest Supervisor that explicitly outlined the vision and goals for the future young-growth timber program on the Tongass National Forest. While the document affirms that a future forest industry will be supported mainly by young growth harvest, it acknowledges that the transition to young growth will be gradual rather than abrupt to allow time for the young trees to mature and allow operators to adjust, adapt, and develop markets for new products (Leaders Intent, January 2013).

While it is pointed out that industry in other parts of the country has been able to transition more quickly than 10-15 years, the direction for the Tongass has been clear that industry will have at least 10-15 years

(see Leader's Intent, January 2013) and USDA Secretary's Memorandum 1044-009 (July 2013) to transition. This length of time is not only to allow for a re-tooling of industry, but will also allow for the current young-growth stands to mature to a point where there are significant acreages of an age and size that could be economically harvested. The Tongass has worked diligently to update forest inventories that have improved our understanding of the age, location, and amount of young growth across the Tongass, and helped clarify the challenges in establishing an economically viable young growth program due to the relatively young age of the available stands. While there is a long history of timber harvest on the forest, large acreages were not harvested until the startup of the pulp mills in the mid-1950s. This means that many of the oldest young-growth stands are still just barely 60 years old. This age is considered to be on the low end of stands that may have economical value.

The comment is a misinterpretation of the reason why the Forest Service cannot move more quickly than 10-15 years. In Chapter 2, the DEIS provided detailed rationale for not carrying forward alternatives that would complete the transition soon (specifically looking at immediate and 5-year timeframes). Based on current demand projections, neither of these alternatives would provide sufficient timber volume to maintain the current industry (Table 2-1) due to the lack of economically viable young-growth timber. The Tongass Young Growth Management Strategy (2016), exhibit 9, shows acres of harvest by suitability by age class. Young-growth acres that were harvested prior to 1960 are fairly limited, but after 1960, there is an increasing amount of young-growth acreage that will be available for harvest making the transition much more feasible in 10-15 years.

Four scenarios were developed in response to USDA Secretary's Memorandum 1044-009 (July 2013). The resulting paper, Scenario Analysis: Young Growth Management on the Tongass National Forest, was completed in August, 2013 but was authorized for internal use at the time. The report analyzed four scenarios related to the transition of the timber program on the Tongass National Forest away from a reliance on old growth forest stands toward a reliance primarily on the harvest of young growth forest stands, to evaluate ways to achieve such a transition within 10-15 years.

The report concluded that the only option that seems to have a realistic chance of achieving the Secretary's goals of implementing the transition to young growth management over the next 10-15 years while maintaining the current forest products industry was to make changes to the Tongass Forest Plan to allow young growth timber to be harvested in most areas where it currently is not allowed (for example, in the beach fringe and riparian management areas), except for roadless and congressionally designated areas. Specifically, the report concluded that:

"There appear to be three ways to transition the Tongass timber program to young growth: wait at least 10 years for young growth stands to mature further before beginning the transition in earnest; provide additional funding for a sustained annual expenditure of several million dollars for a thinning program; or make changes to the Tongass Forest Plan to allow young growth timber to be harvested in most areas where it currently is not allowed, except for roadless and congressionally designated areas.

Only the last option, represented in this paper by Scenario 4, seems to have a realistic chance of achieving the Secretary's goals of implementing the transition over the next 10-15 years while maintaining the current forest products industry.

In addition to modifying the Forest Plan, transitioning under Scenario 4 requires the following:

> "Enactment of the Sealaska Lands bill, S.340 as currently drafted, including the limited exemption from current CMAI requirements." (since completed); and
>
> "Completion of the Alaska Mental Health Trust land exchange."

See above discussion relating to the scenario's analysis. The conclusion was that even with a removal of the requirement to meet Culmination of Mean Annual Increment (CMAI) prior to rotational harvest, the most aggressive scenario analyzed in the Scenario Analysis: Young Growth Management on the Tongass National Forest still requires a timeline of 10-15 years.

In regards to 'delayed regeneration', in Ms. Mater's report from November, 2015, it is stated that "Years to reach breast height is notably different based on stand age: 12 years for stands harvested 50-55 years

ago; 9 years for stands harvested 45-49 years ago; and just 3 years for stands harvested 40-45 years ago." This is not consistent with findings from PNW growth and yield studies and we believe this statement is erroneous. The CSDS data show that the time required to reach breast height (4.5 feet) ranges from 6 to 11 years and typically it takes 7 to 9 years. Counting the annual rings in increment cores under field conditions is subject to considerable error. The age data for the CSDS study was obtained from prepared cores in the laboratory, with magnification used as necessary.

Although a GIS analysis of the entire forest may show enough acres of young-growth, it cannot reflect the great amount of variability in site productivity, growth rates, species composition and access to a mill and/or market across the entire forest, which spans a very large geographical area. These factors are incredibly important when considering and planning for a transition to young-growth. If the young-growth stands are not economically viable at age 55, then they cannot be harvested and therefore do not help contribute to the supply of volume in an immediate transition to young-growth. Many acres, particularly on the more remote districts that do not have mills or other processors like Sitka and Juneau Ranger Districts, will not meet the economic requirements. In accordance with Public Law 113-291, young-growth timber sales may not be offered unless they represent non-deficit sales. A transition to young growth cannot only be based upon modeled, available volumes.

In order to provide updated information to FBRI for the Southeast Alaska library update, the Tongass has funded the Pacific Northwest Research Station's (PNW) Juneau Forestry Sciences Laboratory to remeasure their extensive network of permanent growth and yield plots. The permanent plots of the Cooperative Stand Density Study (a.k.a. the Farr Plots) were established 40 years ago and provide us with the long-term growth response of thinned and unthinned even-aged stands at over 50 locations throughout southeast Alaska. PNW is also monitoring permanent plots established by R.F. Taylor in the 1920s. The long-term growth and yield record from the PNW permanent plots was used to create the southeast Alaskan variant of FPS in 2005 and more recently collected data were used in the 2015 recalibration of the Southeast Alaska library.

Planning Rule (PLR)

COMMENT

PLR-1: The explanation in the DEIS of how the 2012 planning rule applies to the amendment is arbitrary and capricious because the "Forest Service is merely picking and choosing which provisions of each planning rule to apply."

The Forest Service should have complied with section 219.9 since a valid decision document cannot be written without explaining how the amendment complies with the 2012 planning rule's substantive requirements. The Forest Service quotes section 219.14(a)(2) that says the decision document must include: "An explanation of how the plan components meet the sustainability requirements of § 219.8, the diversity requirements of § 219.9, the multiple-use requirements of § 219.10, and the timber requirements of § 219.11."

The 2012 planning rule requires plans to provide for social, economic, and ecological sustainability (36 CFR 219.8), and the preferred alternative is contrary to the provisions in the 2012 planning rule on ecological integrity and ecosystem diversity (36 CFR §§ 219.8(a), 219.9(a)).

The Forest Service is charged with sustaining wolf and wildlife populations at scales smaller than the entire forest. The 2012 planning rule requires plans to maintain and restore ecosystem function on the watershed level because of the following statement from 36 CFR 212.9(a)(1): "As required by § 219.8(a), the plan must include plan components, including standards or guidelines, to maintain or restore the ecological integrity of terrestrial and aquatic ecosystems and watersheds in the plan area, including plan components to maintain or restore their structure, function, composition, and connectivity."

A plan revision is needed to remove the existing Transportation and Utility System overlay LUD under the action alternatives in the DEIS. Under the 2012 planning rule, the amendment process should not be used to add or remove a geographic or management area delineation from a Forest Plan. Instead, the amendment process envisions changing the way in which the Forest Plan components interact with a particular geographic or management area delineation. (36 CFR § 219.13(a)).

RESPONSE

The Forest Service believes that the Agency has followed the requirements for a plan amendment process (36 CFR 219.13) and applied the rule appropriately. The Agency—

Began scoping for the plan amendment with a notice in the *Federal Register* on May 27, 2014, as required by 36 CFR 219.16 (79 FR 30074).

Applied the best available scientific information in analyzing the effects of the proposal and the alternatives, as required by 36 CFR 219.3.

Gave public notice and gave ample opportunities for public participation, as required by 36 CFR 219.4. (See Forest Plan newsroom web page and DEIS p. 1-6.)

Wrote the proposed direction in Chapter 5 of the proposed amended plan in the form required by 36 CFR 219.7(e).

Will give the public an opportunity to object to the proposed decision, as required by 36 CFR 219 subpart B.

Developed the proposed amendment to change substantive direction about timber harvest for purposes of timber production and for other multiple use purposes, including improving wildlife or fish habitat, so that it meets the 2012 Rule's substantive requirements regarding timber harvest for timber production and other multiple-use purposes, as required by 36 CFR 219.11.

Integrated plan components for renewable energy direction and transportation systems corridors into the proposed plan amendment after consideration of the appropriate placement and sustainable management of infrastructure, as required by 36 CFR 219.10(a)(2) and (3).

After careful consideration the Agency has concluded that the only practical way to interpret the 2012 planning rule's application to plan amendments is to focus on the proposed action—the responsible official's proposed action will determine the scope and scale of the change to the plan. To have the scope of an amendment be determined by all the possible resource effects could have a cascading effect, necessitating a broadening of the responsible official's proposed action, and a change to the plan with respect to any and every affected resource.

The rule does not explicitly direct how changes to an "old rule" plan are to be made with "new rule" amendments, but it clearly does not change the fundamental principle that a line officer proposes and decides on an action. The rule provides that "[p]lan amendments may be broad or narrow, depending on the need for change," and that "[t]he responsible official has the discretion to determine **whether** and **how** to amend the plan." (36 CFR 219.13(a)) (emphasis added). The rule reinforces the principle by providing that the rule "does not compel a change to any existing plan." (36 CFR 219.17(c)).

Furthermore, the rule continues to say at 36 CFR 219.17(c) that "None of the requirements of this part apply to projects or activities on units with plans developed or revised under a prior planning rule until the plan is revised under this part, except that projects or activities on such units must comply with the consistency requirement of § 219.15 with respect to any amendments that are developed and approved pursuant to this part." This provision reflects the Agency's intent that an amendment of an "old rule" plan will not require the entire plan to conform to the new rule's substantive provisions (§§ 219.8 through 219.11) and to be subject to the new rule's consistency provisions (§ 219.15).

The following words from the preamble for the planning rule show that the Department does not expect plan amendments to be comprehensive and meet all of the substantive provisions (36 CFR 219.8-219.11) of the planning rule: "[P]lans will be kept more current, effective, and relevant by the use of more frequent and efficient amendments, and administrative changes over the life of the plan, also reducing the amount of work needed for a full revision. Plan amendments incrementally change the plan as need arises. Plan amendments could range from project specific amendments or amendments of one plan component, to the amendment of multiple plan components." (77 FR 21237 (April 9, 2012)).

Because the responsible official has the discretion to determine whether and how to amend the plan, the responsible official has the discretion to determine the specific changes to propose and approve. Here, the forest supervisor has the duty to determine the purpose and need for the proposal. The purpose and need for the specific changes proposed to the Tongass plan do not support making extensive changes to conform the plan to §§219.8-219.10.

The provision in 36 CFR 219.13(a), that the responsible official has the discretion to determine how to amend the plan, has been interpreted by some people to confer discretion regarding the amendment process, but not the scope and scale of the actual proposal. Such an interpretation, however, overlooks the fact that the rule already sets out a required process for plan amendment, at 36 CFR 219.13(b).

Section 219.17(c) clearly states that the rule does not compel any changes to any existing plan. Therefore, the responsible official, not the rule, determines the scope of any amendment. By choosing the scope and scale of the proposed plan amendment, the responsible official determines which of the new rule's substantive provisions or parts thereof are applicable.

The determination of which of the new rule's substantive provisions are applicable, that the amendment meets them, and the finding that the amendment is not opposed to the Rule's substantive provisions must be supported by rationale, as documented in the DEIS.

In this case, the Tongass proposed plan amendment appropriately meets the applicable provisions of 36 CFR 219.11 and 219.10(a)(2) and (a)(3) and will not be opposed to any of the other substantive provisions of the 2012 rule.

With respect to whether removing the existing Transportation and Utility System overlay LUD may be achieved through an amendment, the Rule provides an unequivocal affirmative answer. The last sentence of 36 CFR 219.13(a) states that: "Except as provided by paragraph (c) of this section [regarding administrative changes], a plan amendment is required to add, modify, or remove one or more plan components, or to change how or where one or more plan components apply to all or part of the plan area (including management areas or geographic areas)." (Emphasis added.) The Department added the phrase "including management areas or geographic areas" to the final planning rule to clarify that an amendment is required for any change in how or whether plan components apply to those areas (77 FR 21238). An amendment may remove all the plan components within a LUD and remove the LUD itself.

COMMENT

PLR-2: The proposed plan amendment does not meet requirements for viability, and does not meet the viability requirements of 1982 rule (section 219.19 of the 1982 rule). The proposed amendment would make substantive changes to the existing wildlife standards and guidelines thereby affecting the Tongass National Forest Old-growth Habitat Conservation Strategy. Those changes make the diversity requirements in 36 CFR 219.9 of the 2012 rule applicable. The Forest Service should therefore comply with 36 CFR 219.9.

RESPONSE

The Tongass Land and Resource Management Plan was developed using the 1982 rule. No obligations exist from the 1982 rule, as that rule no longer exists (36 CFR 219.17(c)). Implementing the viability requirement of the now superseded planning regulations, the Tongass Forest Plan contains a goal of providing an abundance and distribution of old-growth habitat to maintain viable populations of wildlife in the forest. The proposed amendment retains that goal in the Old-growth Habitat Conservation Strategy (hereafter 'Conservation Strategy') and the Wildlife Forest-Wide Standards and Guidelines, with plan direction to "Provide the abundance and distribution of habitat necessary to maintain viable populations of existing native and desirable non-native species well-distributed in the planning area (i.e., the Tongass National Forest)." (WILD1IIB, Proposed Forest Plan, p. 4-82).

Whether the diversity requirements of the 2012 rule applies to this amendment is determined by what the responsible official proposes. Here, the proposal is focused on accelerating the transition to young-growth timber harvest. The timber focus of the amendment therefore causes the 2012 rule's timber provisions, at section 219.11, to apply. The proposed amendment would not change the plan's Conservation Strategy for wildlife, and so does not require the application of section 219.9. Even so, the Tongass Old-growth Habitat Conservation Strategy ("Conservation Strategy") in the forest plan meets the intent of the 2012 planning rule to provide the ecological conditions to both maintain the diversity of plant and animal communities and support the persistence of most native species in the plan area. The amended plan also provides the additional species-specific plan components to maintain viable populations. The amended plan, under any alternative proposed, will therefore be at least as protective as 36 CFR 219.9.

At this time, the responsible official does not propose to redesign the Tongass Conservation Strategy in light of 36 CFR 219.9 for diversity of plant and animal communities. In particular, the regional forester is retaining and using the list of Alaska Region Sensitive Species ("sensitive species") for the Tongass and is not designating species of conservation concern (SCC) at this time under 36 CFR 219.9.

The proposed amendment includes plan components to improve habitat conditions in young growth stands and, as part of that direction, to mitigate effects on fish and wildlife, consistent with 36 CFR 219.11(c) and 36 CFR 219.11(d)(3). This amendment triggers section 219.11(d)(3), which requires that timber harvest "would be carried out in a manner consistent with the protection of soil, watershed, fish, wildlife, recreation, and aesthetic resources." Also, section 219.11(c) gives discretion to allow timber harvest for purposes other than timber production including improving fish and wildlife habitat. The amended plan therefore includes S&Gs to mitigate effects of harvest on fish and wildlife.

The plan as amended will continue to fulfill our obligations under the NFMA to "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area to meet overall multiple-use objectives." (16 U.S.C. 1604(g)(3)(B)). The plan as amended would continue the

Tongass strategy to provide for the diversity of plant and animal communities, through management of both ecosystem conditions (the Conservation Strategy) and species-specific conditions (through S&G's) as set forth in the 2012 planning rule at 36 CFR 219.9. This approach is sometimes characterized as the 'coarse-filter/fine-filter' approach to conservation.

The coarse-filter/ fine-filter approach is a complementary ecosystem and species-specific approach to provide for the diversity of plant and animal communities and the long-term persistence of native species in the plan area. This approach is a well-developed concept in the scientific literature and has broad support from the scientific community. Indeed, this approach has been used on the Tongass since 1997.

The coarse filter focuses on ecological integrity, maintaining or restoring characteristics of the environment as expressed by features such as composition, structure, function, and connectivity of ecosystems, to maintain diversity and persistence of native species. Land management units with ecosystems exhibiting a high level of integrity or with plans that maintain and restore ecosystems are assumed to support the conservation of the vast majority of species.

The fine filter, and associated plan components, complements the coarse filter by providing for additional specific habitat needs or other ecological conditions of at-risk species, when the responsible official determines those needs are not met through the coarse-filter.

Implementing the viability requirement of the now superseded planning regulations, the 1997 Forest Plan developed a conservation framework for wildlife and integrated several elements into its Tongass Conservation Strategy. The proposed amended plan retains that framework, including a standard requiring the plan provide the abundance and distribution of habitat necessary to maintain viable populations of existing native and desirable non-native species well-distributed in the plan area. Below we explain the Tongass Conservation Strategy, the history of the Tongass Conservation Strategy, the proposed amendment, the effects of the proposed amendment on the Tongass Conservation Strategy, and the effects of the proposed amendment to species.

The Tongass Conservation Strategy

The Tongass National Forest Old-growth Habitat Conservation Strategy also uses the approach to conservation outlined at 219.9 in the 2012 Rule, the so-called coarse-filter/fine-filter approach to maintain ecological integrity while allowing multiple uses to occur. The Agency designed the Tongass Conservation Strategy to provide the spatial extent, distribution, and connectivity of old-growth forest ecosystems to support well-distributed, viable populations of old-growth associated species. Based on principles of conservation, a network of large, medium, and small sized old-growth reserves (OGRs) allocated to the Old-Growth Habitat Land Use Designation (LUD) plus all small islands less than 1,000 acres remain intact. This largely undisturbed habitat is distributed across the Tongass National Forest. In addition to the broad, ecosystem-focused OGRs, additional conservation measures are provided through the standards and guidelines that apply to timber harvest in the matrix (DEIS, p. 3-186).

The old-growth reserves retain ecosystem integrity by maintaining a functional and interconnected ecosystem. The standards and guidelines applicable to matrix lands ensure ecological conditions that support at-risk species and other old-growth associated species. The plan includes specific direction to provide ecological conditions for many species, including: bald eagle, brown bear, goshawk, heron, marbled murrelet, marten, mountain goat, river otter, deer, and wolf.

At-risk species include federally listed species under the Endangered Species Act (ESA), and sensitive species. No federally listed fish species originate from Alaska streams. Some federally listed fish stocks occur in marine waters near the forest (DEIS, p. 2-110). No federally listed plants occur on the Tongass National Forest. The regional forester identified 16 plants which are known or suspected to occur on the Tongass as sensitive species (DEIS, p. 3-134). Some federally listed wildlife species occur in the marine waters: humpback whale, fin whale, sperm whale, and Steller sea lion (Western Alaskan distinct population segment) (DEIS, p. 3-210).

The proposed amended plan adds standards to protect the Aleutian Tern and black oystercatcher, which were identified as sensitive species since the plan was last amended. Although several species were also

removed from the species list, the proposed amended plan retains standards and guidelines protecting those species.

History of the Tongass Conservation Strategy

The Tongass Old-Growth Conservation Strategy was designed through a collaborative effort by a broad range of scientists, Alaska Department of Fish and Game, and U.S. Fish and Wildlife Service, and underwent intensive peer review. The strategy was initially established as part of the 1997 plan revision process. The Tongass Conservation Strategy was developed to maintain a functional and interconnected old-growth forest ecosystem on the Tongass by retaining intact, largely undisturbed habitat. Outside of reserves, components of the old-growth ecosystem are maintained by standards and guidelines to protect important areas and provide old-growth forest habitat connectivity. A series of expert risk assessment panels prepared viability risk assessments based on this framework. Using the panels' assessments, the Agency determined that there was a moderate to very high probability of maintaining sufficient habitat to maintain viable populations of wildlife species on the Tongass under the 1997 Plan.

The Agency believes those probability estimates are very conservative because the panels of experts assumed timber harvest at 267 MMBF annually for 100 consecutive years, with no change in applicable S&Gs. (ROD 2008, p. 19)

The Tongass Conservation Strategy was designed to take into account extensive timber harvest on non-NFS lands and relied little on non-NFS lands to maintain ecological integrity. (DEIS, p 3-202 to 203). The strategy maintains habitat for well-distributed, viable wildlife populations in the plan area (DEIS, Appendix D, p. D-16).

The 2008 Tongass amended plan added to the Tongass Conservation Strategy a forest-wide legacy forest structure standard, replacing the 1997 goshawk foraging and marten habitat S&Gs. This standard applies to watersheds with high levels of timber harvest. It requires the retention of forest structural components such as patches of large trees, downed logs, and snags (dead trees) after timber harvest.

The 2008 amended plan enhanced the network of small OGRs by reconfiguring the network based on an interagency review to increase habitat protection and to reduce operational conflicts. In addition, the 2008 amended plan increased the amount of land allocated to other non-development LUDs by 69,000 acres, effectively increasing the extent of the old-growth habitat reserves.

In 2015, the National Defense Authorization Act for Fiscal Year 2015 conveyed 69,585 acres of NFS land to the Sealaska Native Corporation. To compensate for the loss of OGR lands, the Agency proposed boundary modifications that would result in a net increase of 6,171 acres of OGR and 7,148 acres of productive old growth (POG) forest included in the reserve system from existing (post-conveyance) levels. (DEIS, Appendix E).

The Proposed Amendment

The proposed amendment accelerates the transition to young-growth timber harvest and makes the development of renewable energy more permissible. The proposed amendment maintains the integrity of the Tongass Conservation Strategy. To ensure the transition does not adversely affect wildlife, the proposed amendment includes standards and guidelines to improve wildlife habitat conditions and long–term ecological function in young growth stands. (36 CFR 219.11(d)). In addition, the proposed amendment makes technical corrections to fix clerical errors, to conform the plan to changes of new statutory or regulatory requirements, and to add explanatory material about how the amendment will apply to projects on the ground.

The proposed amendment accelerates the transition time from primarily old growth harvest to primarily young growth harvest from 32 years to 16 years resulting in a reduction in the extent of old-growth forest harvest. The proposed amendment would change the suitability of specific young-growth stands in beach and estuary fringe, old growth habitat LUD, and riparian areas from "not suitable for timber production" to "suitable for timber production." (DEIS, Appendix D, Table 2, p. D-9).

By shifting away from old-growth harvest, the Agency would preserve undeveloped land in unroaded areas, contributing to unfragmented wildlife habitats. Young-growth timber harvest would occur within the previously harvested footprint and maximizes the use of existing roads to access young-growth stands. The proposed amendment identifies 11 percent of the productive forest land as suitable. However, the proposed amendment would only harvest 0.8 percent of the productive old growth (POG) after 100 years. Under the proposed amendment, the annual PTSQ would be 46 MMBF during the first decade and 56 MMBF during the second decade (DEIS, p. 3-307). Therefore, more old-growth is retained under the proposed amendment than under the current plan. (DEIS, Appendix D, p. D-7).

Alternatives 2, 3, and 4 would relax the S&Gs for “high vulnerability” karst areas. Alternatives 2, 3, and 5 would relax the scenic integrity objectives to allow additional harvest. Given that these non-wildlife S&Gs are not part of the Conservation Strategy, relaxing these S&Gs will have no effect on the functioning of the Conservation Strategy. (DEIS, Appendix D, p. D-16).

Effects of the proposed amendment on the Tongass Conservation Strategy

The Agency has disclosed the effects of the proposed amendment on plant and animal communities in the environmental impact statement. The Tongass Conservation Strategy, particularly the extent and distribution of old-growth habitat, has been found to be stronger than anticipated in the 1997 analysis. Past and projected harvest of old-growth forest are far lower than predicted in 1997. In addition, the Forest Plan designates Inventoried Roadless Areas, even if part of the land within the forest development LUD, as not suited for timber production, subject to the District Court of Alaska’s 2011 judgment reinstating the Roadless Rule on the Tongass (Organized Village of Kake v. USDA, 1:09-cv-00023 (May 24, 2011)). Timber harvest in these roadless areas is prohibited (Appendix D, p D-6). The forest contains about 111,000 more acres of POG today, than was predicted in 1997 (DEIS, Appendix D, D-17). Today, 92 percent of the original productive old growth that was inventoried in 1954 (5.4 million acres) still occurs on the Tongass. Under all alternatives, we estimate 91 percent will remain in 100 years. (DEIS, p. 3-195; DEIS Table 3.9-12).

Within the Old-growth Habitat LUD and other non-development LUDS, young-growth forest stands do have ecological value. Under the action alternatives, openings created by even-aged timber harvest provide abundant forage for deer as sunlight reaches the forest floor enhancing the growth of forage (DEIS, p. 3-217). In addition, thinning of young-growth stands in the stem exclusion stage would also improve the forage for deer for 15 to 25 years (DEIS, p. 3-244). The Tongass Conservation Strategy, as designed in 1997, did not rely on the value of young-growth forest stands when assessing the risk to viability of old-growth associated at-risk species (DEIS, Appendix D, p. D-8). For this reason, and due to the spatial distribution and quantity of suitable young-growth harvest in the non-development LUDs, harvest of young-growth in these areas would pose a zero to very low risk, depending on the selected alternative, to the function and integrity of the Tongass Conservation Strategy that maintains old-growth associated species (e.g., marten, goshawks, flying squirrels). (DEIS, Appendix D, p. D-7 to D-10). Therefore, there would be no change to the functioning of this contributing element of the Conservation Strategy. (DEIS, Appendix D, p. D-8).

The beach and estuary fringe is a 1,000-ft wide corridor adjacent to saltwater shorelines; it consists of productive old growth, unproductive forest, young growth forests, and non-forest types. For all alternatives, due to the very local nature of effects, the beach and estuary fringe would continue to act as an ecological transition zone between interior forest and saltwater influences, maintain landscape connectivity, and provide benefits to the marine environment across the planning area, including sustain habitats for goshawks and bald eagles. (DEIS, Appendix D, p. D-11 to D-13). Therefore, there would be no measurable change to the functioning of this contributing element of the Conservation Strategy. (DEIS, Appendix D, p. D-13).

For all alternatives, the riparian areas would continue to maintain ecological functions of aquatic and terrestrial habitats, maintain water quality, and provide connectivity across the planning area for all the alternatives due to the local and short term nature of effects to the riparian areas. (DEIS, Appendix D, p. D-14). Therefore, there would be no measurable change to the functioning of this contributing element of the Conservation Strategy. (DEIS, Appendix D, p. D-14).

Effects of the proposed amendment to species

Across the landscape of Federal and non-Federal lands within the boundary of the Tongass, ecological conditions (habitat) support viable populations of fish, plants, and wildlife. The likelihood of a wildlife population persisting over time has been suggested to be related to maintaining 20 to 50 percent of the habitat on the landscape (DEIS, p-3-261). Looking at all lands, all of the biogeographic provinces on the Tongass are projected to maintain at least 57 percent of the original (1954) POG after 100 years of Forest Plan implementation under the proposed amendment. (DEIS, p. 3-261).

The Agency prepared a draft biological evaluation (BE) to analyze and document the effects of the proposed action on sensitive species. The review included consideration of the following sensitive species: Steller sea lion (Eastern Alaskan DPS), Queen Charlotte goshawk, Aleutian tern, black oystercatcher, and Kittlitz's murrelet. The overall findings for all sensitive species was that the plan, as amended, may affect individuals but is not likely to result in a trend toward federal listing or loss of viability of the species.

Allowing harvest in young-growth stands in the Old-growth Habitat LUD and other non-development LUDS, the beach and estuary fringe, and the riparian management areas may reduce the local function of these areas to for some species, and but opening up these areas for commercial harvest would also allow for commercial thinning to improve habitat quality in lower value stands. (DEIS, p. 3-237).

All of the alternatives would maintain the integrity of the Conservation Strategy by maintaining the functioning of the system of old-growth reserves in the Old-growth Habitat LUD and other non-development LUDS (DEIS, Appendix D, p. D-8). Also, the effects to the beach and estuary fringe would be short-term (10-15 years) after each entry and more localized in these areas (DEIS, Appendix D, p. D-12. Also, because of the local nature of effects under all of the alternatives, riparian areas would continue to maintain aquatic and terrestrial habitats, maintain water quality, and provide landscape connectivity across the planning area (DEIS Appendix D, p. D-14).

In addition, "all of the alternatives are expected to maintain a functional and interconnected old-growth ecosystem, capable of supporting well-distributed, viable wildlife populations across the planning area; therefore none of them are expected to increase the likelihood of species listing under the ESA." (DEIS, Appendix D, p 18).

The 2012 rule at 36 CFR 219.17(c) makes it clear that the responsible official determines the scope and content of any amendment and therefore determines which substantive provisions of the 2012 rule are applicable. This determination must be supported by rationale and informed by the best available scientific information and cannot be opposed to the applicable substantive provisions of the 2012 rule.

The proposed amendment meets the applicable substantive provisions of the 2012 rule, i.e., 36 CFR 219.11. In addition, the amended plan will meet the intent, if not the letter, of other substantive provisions of the 2012 rule, such as the diversity provisions of 36 CFR 219.9. The amended plan would retain the underlying plan's coarse/fine filter approach to maintain ecological integrity and provide ecological conditions for at-risk species. None of the proposed alternatives would reduce the ability of the Conservation Strategy to maintain a functional and interconnected old-growth ecosystem across the planning area and the overall functioning of the Conservation Strategy in terms of its ability to maintain viable, well-distributed populations of wildlife across the planning area would not be affected. The amended plan will be consistent with the NFMA requirement to "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area to meet overall multiple-use objectives" (16 U.S.C. 1604(g)(3)(B)). Therefore, no additional changes are needed to the amended plan to implement any other substantive provisions of the rule. (36 CFR 219.8 through 219.11).

COMMENT

PLR-3: Concerns were expressed about the approach that was taken to amend the 2008 Forest Plan saying it is confusing and will likely result in decisions that are inconsistent and lead to conflict. The priority of direction now includes both direction from both the 1982 and 2012 planning rules. There is acknowledged variance among standards and guidelines between Chapters 3, 4 and 5 and inconsistent definition of terms. Using the blended planning rule

approach is confusing and would likely contribute to inconsistent and poorly understood decision making.

RESPONSE

Additional text has been added to Chapter 1 of the Forest Plan to clarify; see Priority of Direction.

COMMENT

PLR-4. The proposal implicates wildlife habitat and makes substantive changes to the existing wildlife standards and guidelines previously contained for the Forest Plan Conservation Strategy, and that these changes make the diversity requirements of the 2012 Planning Rule (36 CFR 219.9) applicable.

RESPONSE

See response to PLR-2.

COMMENT

PLR-5: The 2012 Planning Rule represents the best available scientific process for maintaining diversity of plant and animal communities, but the Forest Plan Amendment did not name species of conservation concern, nor employ an updated population viability analysis. The Forest Service must explain that the Forest Plan Amendment complies with NFMA's diversity mandate, and this explanation must be added to the FEIS and record of decision (ROD).

RESPONSE

See response to PLR-2.

COMMENT

PLR-6: The agency is required to identify species of conservation concern to comply with the 2012 Planning Rule's monitoring provisions. Not updating the monitoring plan as part of the Forest Plan Amendment represents a waste of government resources.

RESPONSE

See response to PLR-2 regarding diversity requirements of 36 CFR 219.9.

The plan monitoring program has been modified to meet the requirements of 36 CFR 219.12 (c). The final planning directives, (Forest Service Handbook [FSH] 1909.12, ch. 30, sec. 32.3) provide guidance regarding identifying species of conservation concern (SCC) when transitioning to the plan monitoring program. Because SCC is a new category of species that did not exist before the 2012 Planning Rule, there is no requirement for SCC to be identified and monitored before a plan is revised under the rule.

COMMENT

PLR-7: To comply with 36 CFR 219.14, the Forest Service cannot amend a forest plan under the 2012 Planning Rule without first implementing the four substantive provisions (sections 219.8, 219.9, 219.10 and 219.11). Nothing in section 219.14 or the preamble to the 2012 Planning Rule indicates that the Forest Service intended those explanations to be discretionary.

RESPONSE

See response to PLR-1 for planning rule applicability and PLR-2 regarding diversity requirements of 36 CFR 219.9. Chapter 2 of the DEIS (p. 2-3) explains how the 2012 Planning Rule applies.

The proposed plan amendment adds provisions to and modifies provisions of the 2008 Forest Plan. As explained in Chapter 6 of the amended plan, the 2012 Planning Rule requirements for project consistency with plan components apply only to additions and modifications (36 CFR 219.15(d)).

The Agency has reviewed the wording of both the 1982 planning rule and the 2012 planning rule dealing with the NFMA requirements of providing for diversity of plant and animal communities. The Agency has disclosed the effects to plant and animal communities in the EIS.

The final planning directives, effective January 30, 2015, are now available. These directives are the key set of agency guidance documents that direct implementation of the 2012 planning rule. The Agency's goal is to ensure an adaptive land management planning process that is inclusive, efficient, collaborative and science-based to promote healthy, resilient, diverse and productive National Forests and Grasslands. The final directives will support consistent approaches to achieving the broad goals of the 2012 planning rule.

The 2012 planning rule was developed through the most collaborative rulemaking effort in Agency history. The complete planning rule, including the preamble and rule text, along with other informational materials, is listed in the News section below.

Please see the Collaboration and Public Involvement webpage for information on the collaborative efforts used during development of the rule. Links are also located in the left banner of this website providing information on the history of forest planning; the basics on what's involved in forest planning and why it's important; as well as answers to frequently answered questions (FAQs) about the rulemaking process.

Text has been added to Chapter 1 of the Forest Plan to clarify; see Priority of Direction. Additionally, management approaches have been added to Chapter Five to clarify the intent to consider all resources in Renewable Energy and TSC planning.

COMMENT

PLR-8: Changes made to the old-growth Conservation Strategy in the amendment are significant and trigger compliance with the viability requirements of 36 CFR 219.9 of the 2012 Planning Rule. The approach to modifying the Conservation Strategy without conducting a new viability analysis for each affected species violates NEPA and NFMA.

RESPONSE

See response to PLR-2.

COMMENT

PLR-9: Concerns were expressed regarding the proposed Amendment's "Priority of Direction" in Chapter 1 of the Proposed Forest Plan. The problem with the Amendment's priority of direction is that Chapter 5 plan components were developed under the 2012 Planning Rule without regard to wildlife viability or diversity. Chapter 5 direction now takes priority over all other plan direction, but wildlife diversity was not properly considered in developing those priority components. That represents an arbitrary and capricious agency decision, and it is inconsistent with NFMA and both 2012 and 1982 Planning Rules.

RESPONSE

See response to PLR-1 and PLR-2.

Text has been added to Chapter 1 of the Forest Plan to clarify; see Priority of Direction. Additionally, management approaches have been added to Chapter Five to clarify the intent to consider all resources in Renewable Energy and TSC planning.

Timber (TIM)

COMMENT

TIM-1: Use of the Sustained Yield Limit is incorrect. This limit includes logging on lands not suited for timber production. This violates the National Forest Management Act, the Multiple-Use Sustained-Yield Act, and implementing regulations.

RESPONSE

Refer to Table 3.13-10 in the DEIS. This table shows the PTSQ as compared to the Sustained Yield Limit (SYL) which is the amount of timber, meeting applicable utilization standards, "which can be removed from [a] forest annually in perpetuity on a sustained-yield basis" (16 U.S.C. part 1611(a); 36 CFR 219.11(d)(6)). It is the volume that could be produced in perpetuity on lands that may be suitable for timber production. Calculation of the limit includes volume from lands that may be deemed not suitable for timber production after further analysis during the planning process. The calculation of the SYL is not limited by land management plan desired condition, other plan components, or the planning unit's fiscal capability and organizational capacity. The SYL is not a target but is a limitation on harvest. Chapter 5 of the Forest Plan now includes the following forest-wide timber standard:

S-TIM-01: Not including salvage or sanitation harvest, the quantity of timber sold in a decade may not exceed the sustained yield limit of 2480 million board feet (MMBF).

The PTSQ of each of the alternatives is an indicator of possible future timber supply level that each alternative would produce. PTSQ is the estimated quantity of timber meeting applicable utilization standards that is expected to be sold during the plan period. The PTSQ is also based on the planning unit's fiscal capability and organizational capacity. It should be noted in Table 3.13-10, that the percentage of the SYL that each PTSQ represents ranges from 36 to 54 percent, depending on the alternative, with the preferred alternative representing 38 percent of the SYL. These percentages are for decades 3 and later; for decades 1 and 2 the percentages range from 19 to 27 percent.

COMMENT

TIM-2: Young-growth harvest should increase at a rate equivalent to the decrease in old-growth harvest.

RESPONSE

Page 9 of the Tongass Advisory Committee's Final Recommendations (Forest Plan, Appendix B) refers to replacing old-growth harvest with young growth on a one-to-one volumetric basis. This is addressed in the Forest Plan, Chapter 5 under the Forest-wide Multiple-use Goals and Objectives (Chapter 2) section where forest-wide timber objectives O-TIM-01 and 02 refer to offering a combination of old growth and young growth to meet demand. Forest-wide objective O-TIM-01 refers to the one-to-one exchange where it states …"When young growth offered is less than 41 MMBF, provide old growth to make up the difference and achieve the annual market demand of 46 MMBF."

COMMENT

TIM-3: The Forest Service should cease its practice of implementing project-specific plan amendments to facilitate timber sale planning at the expense of the Conservation Strategy.

RESPONSE

See response to PLR-1.

A plan amendment process relies on the Responsible Official's identification of the need to change a plan. If a proposed project is not consistent with the plan, the Responsible Official has the option to start a plan amendment that, if approved, would accommodate the project. The final planning directives (FSH 1909.12, chapter 20, section 21.31) provide guidance for project-specific plan amendments and administrative review.

See Management Approaches for Wildlife in Forest Plan Chapter 5, Young Growth plan content.

COMMENT

TIM-4: The Forest Service should release a full and detailed sale schedule for the transition and identify the caps that will not be exceeded during Transition Years.

RESPONSE

The Woodstock model analysis involved first maximizing young-growth harvest under a non-declining even flow and then adding old-growth volume to reach an annual average harvest of 46 MMBF and maximizing the net present value. The alternatives were designed to include the maximum amount of young growth that can be sold on a sustainable basis, but this amount is limited by the economics of young-growth harvest. Figures 3.22-12 to 3.22-16 in the Final EIS display the amount of young-growth and old growth projected to be sold during 5-year periods, based on modeling. However, these amounts would be affected by the actual annual demand, market fluctuations, NEPA-cleared volumes available, and other factors, so specific limits on old-growth harvest cannot be committed to in advance. The only commitment that can be made is that young-growth volume will replace old-growth volume over time as rapidly as the economic availability of young-growth allows (see the response to Comment TIM-2).

FSH 1909.12, Section 22.34 states that the plan should not include a “to do” list of projects and expected dates. While a full and detailed schedule for the next 5 years is certainly desirable and every effort will be made to obtain it, it is not immediately able to be produced. An intense inventory of young growth is just now begun in collaboration with the State of Alaska to get information that will better enable the Forest Service to identify those areas of both young growth and old-growth that meet the criteria of feasible, economic offerings and meet all Forest Plan Direction.

Two tables have been added to Forest Plan Appendix A. 1) Vegetation Management Practices (acres) Annual Average per Decade; and 2) Average volume outputs for the 1st and 2nd decades for Tongass National Forest planned timber sale program.

In addition, the following forest-wide timber standard has been added to Chapter 5 of the Forest Plan:

> S-TIM-01 Not including salvage or sanitation harvest, the quantity of timber sold in a decade may not exceed the sustained yield limit of 2480 million board feet (MMBF).

COMMENT

TIM-5: The Forest Service should manage on an even-flow, long-term sustained yield basis.

RESPONSE

The Tongass is currently and will continue to manage on a non-declining even-flow as required by the National Forest Management Act. (See Pub. L. 93-378, §13, as added Pub. L. 94-588, §11, Oct. 22, 1976, 90 Stat. 2957.) For the Forest Plan in 1997 and in 2008, the Allowable Sale Quantity was determined for suitable lands. It was determined that 267 MMBF/year could be harvested on the suitable lands on an even-flow, long-term sustained yield basis. The analysis in this EIS determines how much all lands that carry productive forest land could produce if these lands were not withdrawn from the suitable base due to legislated or administrative withdrawals. This is the sustained yield limit (SYL). Projected Wood Sale Quantity (PWSQ) is an estimate of the volume of all timber and other wood products that is expected to be sold during the plan period from expected harvests for any purpose (except salvage harvest or sanitation harvest) on all lands in the plan area. The PWSQ includes all woody material likely to be sold from these harvests whether or not the woody material meets the utilization standards. The Projected Timber Sale Quantity (PTSQ) is an estimate of the volume of timber that is expected to be sold. PWSQ and PTSQ must take into account the fiscal capability of the planning unit and be consistent with all plan components. The PWSQ and PTSQ have been determined in the proposed Forest Plan and includes both young-growth and old-growth yields.

Two tables have been added to Forest Plan Appendix A. 1) Vegetation Management Practices (acres) Annual Average per Decade; and 2) Average volume outputs for the 1st and 2nd decades for Tongass National Forest planned timber sale program.

In addition, the following forest-wide timber standard has been added to Chapter 5 of the Forest Plan:

S-TIM-01 Not including salvage or sanitation harvest, the quantity of timber sold in a decade may not exceed the sustained yield limit of 2480 million board feet (MMBF).

COMMENT

TIM-6: The Forest Service should not allow old-growth clearcutting as part of a stewardship contract. Concerns were expressed in reference to the Big Thorne Stewardship Integrated Resource Timber Contract where this sale included thinning of young growth stands that provided stewardship credits for large old-growth clearcuts. This does not follow the original intent of stewardship contracts.

RESPONSE

Stewardship contracts are but one mechanism for funding resource enhancement projects. Stewardship was not used for years in the Alaska Region even though it was used elsewhere in the Forest Service for the very reason you mention. However, by not using the money generated from stewardship contracts, we were losing the opportunities to fund not only precommerical thinning, but also other projects such as trail restoration and stream enhancement. As we transition to young-growth, less and less old-growth forest will be harvested and eventually stewardship contracts may not be used for the remaining old-growth harvest.

COMMENT

TIM-7: Ecological concerns should be considered as a priority as part of "favorable logistical access" in Timber Sale planning.

RESPONSE

The first management approach for young-growth in Chapter 5 of the Forest Plan states: "The intent is that young-growth areas are generally treated in priority of most return and least environmental risk." Favorable logistical access is an economic criteria and is considered along with "least environmental risk."

Additional management approaches for young growth provide the intent for integrated resource management when designing projects. For example, "The intent is that responsible officials engage stakeholders (for example, conservation interests, timber operators, permitted user groups, and other interested parties) early and often to best design projects that meet ecological, social, and economic interests. Such inclusion would surface and resolve differences, and minimize and avoid social, environmental, and natural resource conflicts."

COMMENT

TIM-8: Trees are a renewable resource and removal of old-growth habitat is not an irreversible commitment.

RESPONSE

Irreversible includes loss of future options, primarily for non-renewable resources but also includes those that are only renewable over long periods of time. Under the current Forest Plan 100 year rotation, young-growth timber in development LUDs would be re-harvested before the stands develop old-growth characteristics (150+ years). Following complete removal of the overstory, it may take 300 years or more for a stands in Southeast Alaska and Northern coastal British Columbia to develop old-growth ecological characteristics (Orians and Schoen 2013). Therefore, clearcut timber harvest creates a permanent loss of old-growth habitat within development LUDs and a permanent reduction of habitat capability to support old-growth associated species.

COMMENT

TIM-9: A complete inventory and a better growth model are needed for young growth.

RESPONSE

The Tongass has conducted young growth inventories covering 60,000 acres and we are planning new inventories of all young growth stands over 55 years old and 15,000 acres in stands 40 to 55 years old. Additionally, The Forest Planning and Projection System (FPS) growth and yield model is well tested and calibrated with long-term growth and yield data from Pacific Northwest.

See response to P&N-4.

COMMENT

TIM-10: Agency fails to completely identify Tongass lands not suited for timber production. The Forest Service should remove all unsuitable lands from the development LUD Group in the FEIS to assure the public that the Projected Timber Sale Quantity is consistent with all plan components. Neither the public nor agency must await a Plan Revision before removing these unsuitable acres from the timber base.

RESPONSE

The model implementation reduction factor (MIRF) is intended to capture those acreages that have been mapped as "suitable" but are actually not suitable due to unmapped streams or unstable slopes or other resource features that would preclude timber harvest. See the Forest Plan FEIS, Appendix B, pp. B-17, B-23 and B-24. MIRF does not influence how much is scheduled but rather helps identify how much is available for scheduling. We start out with the mapped suitable lands, which represents what is suitable based on GIS mapping. Then we apply the MIRF and reduce the acreage of the mapped suitable, producing an estimate of the actual suitable acreage. Finally, the scheduled suitable acreage is that acreage that was needed to meet the outputs over 100 years based on the Woodstock model. An explanation of how the scheduled acreage was determined has been added to the FEIS, Appendix B. The suitable acres not scheduled are not harvested because of economics or they were not needed to achieve modeling objectives. The acres are still considered to be suitable and may be harvested in the next planning cycle if they still meet the criteria for suitable at the time.

During forest land and resource management planning, the Forest Service is required to identify lands suited and not suited for timber production (36 CFR 219.11). Suitability of Lands is considered a plan component in the 2012 Planning Rule, and modifying or removing suitable lands requires a plan amendment. The Forest Service followed the guidance in Forest Service Handbook (FSH 1909.12, chapter 60) to meet the requirements in 36 CFR 219.11. A review of the suitable lands was completed for Alternative 5 (preferred alternative) and it is displayed in Appendix A of the Forest Plan. This has been carried forth and unsuitable acres have been removed from the timber base.

Proposed LUD changes common to the action alternatives are described in Chapter 2 of the FEIS. No other LUD changes are proposed to remove the lands not suited for timber production from the Development LUDs and incorporate these lands into the natural setting LUDs because that would require additional scoping.

COMMENT

TIM-11: The proposed Forest Plan objective O-TIM-01 violates the Tongass Timber Reform Act (TTRA) because it essentially makes the planning cycle demand projection of 46 MMBF into an annual timber target.

RESPONSE

As discussed in Appendix G to the Draft EIS, Section 101 of the 1990 Tongass Timber Reform Act (TTRA) states:

> Subject to appropriations, other applicable law, and the requirements of the National Forest Management Act of 1976 (Public Law 94-588), except as provided in subsection (d) of this section, the Secretary shall, to the extent consistent with providing for the multiple use and sustained yield of all renewable forest resources, seek to provide a supply of timber from the Tongass National Forest which (1) meets the annual market demand for timber from such forest and (2) meets the market demand from such forest for each planning cycle.

Starting in 1990, the PNW Research Station has developed a series of trend projections that estimate market demand for each planning cycle (Brooks and Haynes 1990, 1994, 1997; Brackley et al. 2006a, Daniels et al. 2016). These studies address the planning cycle demand portion of TTRA's "seek to meet" requirement. The Forest Service developed the Morse methodology in 1990 as a means to comply, year-to-year, with the annual demand portion of the "seek to meet" requirement. This is discussed further in Appendix G to the Draft EIS.

The comment is concerned that a new Forest Plan objective for Timber (O-TIM-01) included in the Draft Forest Plan essentially makes the latest planning cycle projections (Daniels et al. 2016) equivalent to meeting annual market demand, with the level fixed at 46 MMBF each year. This is not the case. The Morse methodology will continue to be used to comply, year-to-year, with the annual demand portion of the "seek to meet" requirement. The Forest-wide multiple-use objectives O-TIM-01 and O-TIM-02 have been revised in the Final Forest Plan to make this clearer and avoid further confusion.

COMMENT

TIM-12: The legacy forest structure standard should be designed specifically for young-growth harvest, and new Forest Plan components should consider the amount and distribution of residual old-growth and require retention of additional young-growth as necessary to meet the intent of the standard. The Forest Service should develop guidance on treatments that would accelerate succession of retained young-growth toward old-growth conditions. If retention of structure in young-growth stands would delay the transition to primarily young-growth harvest, additional alternatives that use a longer transition period should be developed and fully evaluated.

RESPONSE

Alternatives 3 and 4 included the following management approach for wildlife (FEIS Appendix F):

"When implementing young-growth timber harvest projects larger than 20 acres in VCUs that have had concentrated past timber harvest, it is intended that 30 percent of the young growth stand acres should be left. The purpose is to retain sufficient residual trees to diversify the structural characteristics of the stand and provide for future recruitment of snags. The VCUs where this is intended to apply are ones in which 33 percent or more of the productive old growth has been harvested since 1954. (Consult Forest Plan Chapter 4 under Wildlife section (WILD1), IV. Legacy Forest Structure.)"

Forest-wide wildlife standard for Legacy Forest Structure in Chapter 4 in the Forest Plan was clarified to make this more clear by adding the following clarification:

"The list of VCUs where Legacy Standards and Guidelines apply should be verified during project-specific planning and analysis based on the harvest standards above."

Specific stand treatments are determined at the project level after site-specific analysis by an interdisciplinary team (IDT), and the IDT can recommend the use of legacy retention or similar measures to the responsible official through the harvest prescription or as project mitigation measures.

In responding to the USDA Secretary's Memo (1044-009), the Forest Service identified the need (in Purpose and Need) to expedite the transition away from old-growth timber harvesting and towards a forest products industry that uses predominantly second-growth – or young-growth – forests. The goal is to "transition over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth." A longer transition period does not meet Purpose and Need. Action alternatives are not "reasonable" if they do not respond to the purpose and need for the action.

Developing additional alternatives outside the range of alternatives analyzed in the DEIS would require a supplement.

COMMENT

TIM-13: The Forest Plan authorization for clearcutting young-growth is arbitrary and does not include a justification for clearcutting. The DEIS never considers whether clearcutting should be the primary method for removing trees given that less destructive means of removing the trees are available. Clearcutting it is not the optimum method if there other ways to achieve regeneration goals, such as maintaining stands of Sitka spruce or Alaska yellow cedar within timber units, or through pre-commercial or commercial thinning.

RESPONSE

The silviculture prescriptions, such as clearcutting or thinning, are not decided at the Forest Plan level. Therefore, a justification for clearcutting is not required. Any clearcut prescriptions at the project level will have a justification at that time. The Forest Plan has the latitude for all prescriptions to be used (see Chapter 4 of the Forest Plan, Timber section, Silvicultural Examination and Prescription: TIM2) and further direction is provided in the Forest Service Handbooks.

The timber section in Chapter 3 of the FEIS, Table 3.13-8 displays the timber management practices as *modeled*. As explained in the text, this does "not limit the manager's ability to use any regeneration method to best meet project goals and objectives."

COMMENT

TIM-14: The Forest Service should take closer account of the TAC's detailed recommendation that if any suitable young-growth acres are removed from the timber base as a result of future review processes, an equal number of acres should be added to the young-growth base.

RESPONSE

Alternative 5 is based on the Final Tongass Advisory Committee (TAC) Final Recommendations (Forest Plan, Appendix B). Under Alternative 5, areas identified as not suited for timber production are partially based on the Land Use Designation (LUD). On Page 4 of the TAC recommendations, *Overarching Principles* (4) states "Co-intent occurs on all suitable and non-suitable acres, and with proper S&Gs can work to meet multiple uses associated with the Forest." However, on page 6, under *Recommendations for Land Use Designations and Standards and Guidelines*, the TAC recommended that "the USFS does not seek young growth volume or change S&Gs…" in specific non-development LUDs and areas (e.g., Remote Recreation LUD, roadless areas, high vulnerability karst, steep slopes).

The only Forest Plan LUDs not included in this list that address forested land as not suited for timber production are the Research Natural Areas LUD and Experimental Forest LUD. Research Natural Areas are unmodified environments where natural processes prevail and therefore do not lend themselves to timber production and young-growth harvest would be incompatible. Experimental Forests are to be managed for the purpose for which they were established. Young-growth harvest has occurred in the Maybeso Experimental Forest for research needs rather than for timber production goals.

The TAC did recommend to "Fully utilize currently allowed prescriptions in beach buffer, Old Growth Reserves, and Riparian Management Areas (RMAs) (outside of TTRA) that improve fish and wildlife habitat and create a commercial by-product." Further, young growth volume produced from these treatments should be counted toward the Projected Timber Sale Quantity (PTSQ) (Page 7 for Final TAC Recommendations). These were included in Alternative 5 (DEIS, p. 2-34).

To represent a more complete application of young-growth harvest on lands suited for timber production, Alternatives 2 and 3 would allow harvest in both development and non-development LUDs, except for Congressionally designated and administratively withdrawn areas and islands < 1,000 acres. In addition, Alternative 2 also considered the portions of inventoried roadless areas (IRAs) that were roaded before the 2001 Roadless Rule and during the 2001 Roadless Rule exemption period for the Tongass to be

suitable for young-growth and old-growth harvest, after rulemaking to modify 36 CFR 294.13(b)(4). Alternative 3 assumed 2001 Roadless Rule changes would occur, and considered lands in 2001 Roadless Rule IRAs to be suitable for timber production after rulemaking to modify 36 CFR 294.13(b)(4). Therefore, these two alternatives expand the suitable young-growth timber base as part of the range of alternatives considered in the DEIS.

COMMENT

TIM-15: The Forest Service should take closer account of the TAC's detailed recommendations, including additional federal aid, new policies for planning and overseeing sales, and new oversight panels.

RESPONSE

These recommendations, while important, are not part of the analysis for the impacts of the Forest Plan amendment on various resources. Rather, they are items that will come into play during the implementation of the amended Plan, if adopted. These items are more dependent on outside influences rather than things that can be developed for a Forest Plan. While the timber demand calculation does come into play in providing a reliable supply of timber, there is no way to guarantee this supply primarily due to the fact that most of our timber harvest projects are litigated and the decision to implement them is often dictated by the courts.

COMMENT

TIM-16: One entry into the beach and estuary fringe will not advance the stand to late seral stage, especially if a 200-foot strip is left along the shoreline.

RESPONSE

The young-growth plan components and management direction for Beach and Estuary Fringe (BEACH) in Chapter 5 of the Forest Plan are based on the Tongass Advisory Committee recommendations (Alternative 5).

The integrity of the Conservation Strategy was included as an issue for the proposed Forest Plan Amendment; one part of that concern was the effect harvest within contributing elements of the Conservation Strategy (such as the beach fringe, RMAs, and Old-growth Habitat LUD) could have on wildlife species that depend on these areas for part or all of their life cycle. Limited young-growth harvest is allowed in these areas under the 2008 Forest Plan but because the volume from any trees cut or removed does not count as commercial timber volume, these treatments are often prohibitively expensive and therefore not utilized or result in heavy slash accumulation that reduces the effectiveness of the treatment as a habitat improvement. The proposed changes to the Forest Plan under Alternative 5 would make it easier to include these stands along with nearby young growth in traditional development LUDs and allow for more flexibility in choosing a harvest prescription that will benefit the stand.

The plan amendment is designed to produce a transition to young-growth management over the next 10-15 years (life of the plan). Under Alternative 5, we do not foresee a need to enter the young-growth stands in the beach, RMA, and Old-growth Habitat LUD more than once during that timeframe. Under the proposed Forest Plan, there are young growth standards that constrain re-entry in these areas unless there is scientific justification to do so. (See S-YG-BEACH-02, S-YG-RIP-02, and S-YG-WILD-02 in Chapter 5.) Habitat improvement projects could also be conducted in the future to meet LUD objectives (current process).

Alternative 5 does not prevent treating all young-growth acres in the beach, RMA, and Old-growth Habitat LUD, but does set standards for those treatments and establishes desired conditions. All young-growth acres could be treated with commercial thinning (up to 35 percent removal) or up to 35 percent of the stand acres could be harvested if an even-aged prescription is used. Site specific analysis at the project level will compare the existing stand characteristics to the desired conditions and determine if and how the stand should be treated to achieve the desired conditions; some acres may already be moving toward old-growth conditions naturally while others may be in a dense, stem exclusion phase requiring treatment.

A buffer immediately adjacent to the shoreline would contribute to future structural complexity of the stand. It would provide a minimal wind buffer, some snow interception, provide for wildlife movement, or the trees/root systems could be used as denning sites for marten or river otter. The trees may be large enough, or approaching the size needed, to be used as perching or roosting trees for eagles. Likely these trees are beginning to produce cones and can serve as a seed source for the adjacent harvest.

COMMENT

TIM-17: The Forest Service should modify its use of the term "young-growth." Suggestions included defining it to include 130-150 year old trees or, conversely, that this is too old and an age of 40 to 80 years is more appropriate.

RESPONSE

Young growth stands that would be harvested under the proposed amendment are typically a minimum of 65-75 years old (DEIS page 3-310), and have not yet reached the understory reinitiation stage which occurs at around 150 years of age in Southeast Alaska (Alaback 1984). See Forest Plan Chapter 7, Glossary. On the Tongass, a forest younger than 150 years old is considered young-growth forest.

COMMENT

TIM-18: Why was the TAC only given 10-15 years to make the transition happen? The transition in such a short time is destined to fail.

RESPONSE

Please see Response to P&N-1. The timeframe of 10 to 15 years came from the Secretary's Memorandum 1044-009 that directed a "transition over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth." This was used as a goal for the design of the TAC alternative and the action alternatives analyzed in the FEIS. As can be seen, in Chapter 2 of the DEIS, two of the alternatives fully achieved this goal and three alternatives, including the TAC alternative, required more than 15 years to fully transition.

COMMENT

TIM-19: The DEIS and Forest Plan failed to consider plan components that reduce the scale and size of old-growth clearcuts. The DEIS identifies NFMA requirements to limit clearcutting, and national directives to limit clearcutting except when essential to meet Forest Plan objectives, but then it arbitrarily picks out timber economic objectives from the Forest Plan to the exclusion of multiple use objectives. [DEIS at 3-299-300].

RESPONSE

The purpose and need and the resulting scope of this amendment does not include limiting the size of old-growth clear cuts. Currently, most old-growth clear cuts on the Tongass are less than the maximum allowed under NFMA. The DEIS section referred to in the comment simply describes the options that are available for timber management. As the transition occurs, old-growth timber harvest will be reduced, thus also reducing clearcutting of old-growth stands. See forest-wide timber objective O-TIM-01 in Chapter 5.

COMMENT

TIM-20: The Forest Plan failed to develop measures to respond to Alaska Yellow Cedar Decline. Harvest of healthy Alaska Yellow Cedar should be limited with the goal of maintaining healthy stands.

RESPONSE

While there is much of uncertainty on the effects of continuing climate change on Alaska yellow-cedar (AYC) populations and regeneration, the Forest has ensured long-term survival by allocating much of the Alaska yellow-cedar's range on the Tongass to non-Development LUDs, while also practicing active forest management like thinning and planting to encourage future establishment and survival of future

AYC trees. All of these practices are already part of the Forest Plan, TIM-2, and will continue to be practiced.

A report, A Climate Adaptation Strategy for Conservation and Management of Yellow-Cedar in Alaska, PNW-GTR-917, January 2016 (Hennon et al., 2016) acknowledges that the health of yellow-cedar varies throughout its extensive range, with nearly 600,000 acres of declining trees mapped. Within these areas, up to 70 percent of the Alaska yellow-cedar are dead and/or dying from climate caused cedar decline. Although it is declining in some areas, in northern areas of Southeast, the tree appears healthy and the projections for its survival is optimistic. Hennon et al., 2016 acknowledges that while yellow-cedar may be declining at a fast rate in some areas, the species is unlikely to become extinct according to models that have projected survival to the year 2080.

According to Hennon et al., 2016, active forest management offers the most direct opportunity for adapting to climate change and responding to yellow-cedar decline (page 189). Forest management practices can increase the abundance of yellow-cedar in habitats that are expected to be favorable into the future, and other approaches can be used to restore some ecosystem functions in decline-affected forests. The Tongass has used precommercial thinning and tree planting to favor Alaska yellow-cedar in areas where they can be expected to thrive in the future.

The Tongass has planted over 1000 acres of Alaska yellow-cedar since 2012, selecting recently harvested areas that are north facing, higher elevation and contain well-drained soils in an effort to re-establish cedar seedlings in areas that will be best suited for survival in a changing climate. While deer predation can cause mortality in young AYC trees in some areas, the Tongass has worked in conjunction with the U.S. Forest Service, Pacific Northwest (PNW) Research Station, Sealaska, and Oregon State University to conduct studies to determine successful methods to ensure seedling survival. The Forest also precommercially thins between 5,000 to 7,000 acres of young conifer stands a year. Since approximately 1990, Alaska yellow-cedar has been the preferred species in nearly all contracts, allowing growing space free from competition from the faster growing Sitka spruce and western hemlock. On the other hand, past practices favored Sitka spruce. Therefore older young growth stands are predominately spruce and hemlock with a very low cedar component.

The Center for Biological Diversity petitioned for listing Alaska yellow-cedar for endangered status under ESA in July 2014. The U.S. Fish and Wildlife Service ruled in April 2015 that the petition warranted further research, but a final ruling has not been issued.

COMMENT

TIM-21: The Forest Service should stop harvesting old-growth and mature young-growth immediately or within 5-years. Currently planned old-growth timber sales should be stopped.

RESPONSE

Refer to ALT-3 and ALT-4.

Conservation Strategy (CONS)

COMMENT

CONS-1: The changes proposed in the Forest Plan, such as implementing silvicultural treatments on a programmatic scale without any scientific support for its assumptions and conclusions, adversely affect the long-standing wildlife Conservation Strategy. The DEIS does not disclose or analyze the broad scope of these changes, or consider the significant uncertainties and unknown risks associated with plan components for commercial thinning and patch clearcuts in protected areas. The Forest Service also ignores relevant science that has developed since the 2008 Forest Plan was adopted, including science that questions many of the assumptions of the Conservation Strategy itself. All of these considerations are exacerbated by the fact that the Proposed Forest Plan dramatically changes the agency's approach to resolving conflict between plan provisions. Under the Proposed Forest Plan, Chapter 5 would prevail over the rest of the plan in the event of conflict or discrepancies between directions. the consequences of this dramatic change in management is not addressed in the DEIS.

RESPONSE

The Tongass Conservation Strategy was designed to maintain viable and well distributed populations of old-growth associated species. Most of the proposed changes in this amendment pertain to young-growth; old-growth harvest remains unsuitable in conservation areas such as non-development LUDs, beach and estuary fringe, and riparian management areas. Completely changing the Conservation Strategy to a different approach would be outside the scope of this amendment.

This amendment considers effects of allowing young-growth harvest and renewable energy siting in contributing elements of the Conservation Strategy (beach, RMA, and Old-growth Habitat LUD).

DEIS Appendix D contains a review of possible effects to Conservation Strategy changes that are proposed, such as young-growth harvest in the beach fringe. Forest-wide, suitable acres of young growth in the beach fringe, RMA, and Old-growth Habitat LUD are about 2 percent, 4 percent, and 3 percent of the total acres in that component, respectively. Projects must still maintain landscape connectivity per WILD1.VI.A (Chapter 4) and several Young Growth plan components inChapter 5 set constraints and expectations on young growth harvest:

DC-YG-01 references sustaining diversity and productivity of ecosystems;

DC-YG-03 and DC-YG-04 reference maintaining or improving fish and wildlife habitat by accelerating old-growth conditions;

GL-YG-01 provides a constraint for maintaining or improving habitat conditions at the landscape level;

DC-YG-BEACH-01 states that the beach and estuary fringe provide habitat and connectivity for wildlife and opportunities for accelerating old-growth characteristics;

S-YG-BEACH-01 and 02, S-YG-RIP-01 and 02, and S-YG-WILD-01 and 02 set constraints for maximum limits on opening sizes and allow for only one entry per stand in the beach fringe, RMAs, and Old-Growth Habitat LUD;

S-YG-BEACH-03 provides a constraint for a minimum 200-foot-wide forested no commercial harvest corridor;

DC-YG-RIP-01 states that RMAs are managed to accelerate old-growth characteristics in order to improve riparian functions for soil, water, fish, wildlife, and other resources; and

DC-YG-WILD-02 states that in the Old-Growth Habitat LUD young growth stand treatments emulate the natural scale and distribution of disturbance patterns.

In addition several management approaches in Chapter 5 explain the intent of implementation for these plan components.

For renewable energy sites, DC-RE-02 states that renewable energy resources are developed in a manner that would maintain and protect NFS lands and resources; a management approach for renewable energy was added to the Forest Plan that explains the intent that renewable energy plan components do not change the need to ensure that resource protection measures are incorporated during project-level planning, construction, and operation of renewable energy sites.

The Forest is not changing its approach to resolving conflict between provisions of the Plan. Under the 2008 Forest Plan, Chapter 3 direction (LUD-specific standards and guidelines) prevailed over Ch. 4 (Forest-wide standards and guidelines) just as it does under this Forest Plan; this amendment simply adds that Chapter 5 direction, which is new, prevails over Chapter 3 only in the event of conflicting direction. Standards and guidelines in Chapters 3 and 4 still apply except in a few instances where Chapter 5 provides a specific plan component such as suitability for young-growth harvest that would be relevant to a particular project. In Chapter 1 of the Forest Plan, under the Priority of Direction section, t content was added to make clear that when applying Chapter 5 direction, all laws, regulations, and policy pertaining to management of National Forest resources will be followed, such as Clean Water Act, Endangered Species Act, and approved best management practices to avoid, minimize, or mitigate environmental impacts.

Silviculture prescriptions, such as clearcutting or thinning, are not decided at the Forest Plan level; a model was run to allow resource specialists to analyze potential effects but this does not limit the options available to be implemented at the project level after site-specific analysis. See also TIM-13 response regarding silvicultural prescriptions

COMMENT

CONS-2: The Proposed Forest Plan disregards the original Tongass Conservation Strategy, which was set up to protect apex predators. The Proposed Forest Plan pushes back the original sideboards of the Conservation Strategy. This is most dramatically evident on Prince of Wales Island, where 94 percent of the contiguous large-tree old-growth stands have been eliminated since 1954 (Albert and Schoen 2013). As a result, we can expect significant declines in Sitka black-tailed deer populations. The preferred alternative in the Proposed Forest Plan will erode the original Tongass Conservation Strategy, increase risks to the Archipelago wolf, and is contrary to the provisions in the 2012 planning rule on ecological integrity and ecosystem diversity (36 CFR. 219.8(a), 219.9(a))

RESPONSE

See responses to CONS-1, PLR-2, WOLF-3, and WOLF-5, and EIS Appendix D.

Overall, the Conservation Strategy is functioning under conditions that are much better than anticipated at the time of its development. Actual and projected old-growth harvest levels under the current Forest Plan (Alternative 1) are far below levels predicted under the 1997 Forest Plan, which formed the context within which the [original] Conservation Strategy was intended to function. This has occurred largely because of economics and a significant decline in the timber industry due to various factors (Appendix D, FEIS).

This Forest Plan reduces the amount of old-growth harvest in about 10-15 years, while increasing the amount of young-growth harvested. During this transition timeframe, harvest of old-growth will occur in the same land use designations as the 2008 Forest Plan (Timber Management, Modified Landscape, and Scenic Viewshed) and is within the effects considered and disclosed in the 1997 and 2008 Forest Plan Conservation Strategy analyses. The Forest Plan also allows for young-growth harvest in portions of the contributing elements of the Conservation Strategy (e.g., beach and estuary fringe, RMAs, and non-development LUDs). Proposed modifications to contributing elements of the Conservation Strategy under the action alternatives have the potential to result in localized reductions in the functioning of these elements. That is, young-growth harvest may locally alter forest structure and reduce connectivity, but the beach and estuary fringe and RMAs would continue to function as intended across the planning area by serving as ecological transition zones, maintaining freshwater and marine aquatic and terrestrial habitat, and providing landscape connectivity (Appendix D, FEIS). The Forest Plan includes several plan components that ensure that young-growth projects would maintain habitat and connectivity for wildlife

and opportunities for accelerating development of old-growth characteristics. (See Forest Plan Chapter 5 young growth direction.) The young growth direction also includes management approaches that describe the principal strategies and program priorities the Responsible Official intends to employ to carry out projects and activities developed under the Plan. Management approaches are intended to assist the IDT to design projects that would maintain or move the forest toward desired conditions. (See Chapter 6, Project Consistency Requirements.)

The Forest Plan is a programmatic document that sets guidance for activities Forest-wide. Including specific components for one location, for example Prince of Wales Island, are generally not included in programmatic direction.

The 94 percent (Albert and Schoen 2013) large-tree reduction since 1954 pertains to high-volume stands which are defined differently by Albert and Schoen (2013) than large-tree for the Forest Service analysis. Further, this reduction is true of the existing condition, not a result of this plan amendment.

In addition, the numbers calculated for the Forest Plan amendment do not match those of Albert and Schoen (2013) for either large tree or high volume: page 3-204 of the DEIS shows original acres of high-volume in the North Central Prince of Wales biogeographic province on all lands (NFS and non-NFS) to be 479,014 acres with 54 percent remaining and page 3-205 shows large-tree POG in that province to be 235,402 acres with 50 percent remaining while Albert and Schoen indicate 77,536 hectares (about 191,514 acres) of original high-volume with 6 percent remaining.

COMMENT

CONS-3: Alternative 5 is not an acceptable alternative because it compromises the integrity of the Conservation Strategy. The Forest Service has concluded that the "beach fringe was a very key feature of the overall Tongass Conservation Strategy." Beach and riparian buffers are essential to maintaining viable populations of old-growth dependent wildlife and marine-associated species. The Forest Service should not relax protections for the areas by allowing young-growth harvest in them. The Forest Service has not properly accounted for the major impacts that would result from relaxing protections for these areas.

RESPONSE

Beach fringe and riparian management areas provide landscape connectivity functions and old-growth habitat for numerous species. These areas are not suited for old-growth timber production as in the 1997 and 2008 Forest Plans. In some cases, young growth in these areas is not functioning to its potential as forested habitat; the desired condition for such stands is to accelerate development of old-growth characteristics, maintain habitat and connectivity, and emulate the natural scale and distribution of disturbance. Several species-specific standards and guidelines also remain in place, such as nest and den buffers and protection of waterfowl and shorebird habitat. Each project decision must say how the project is consistent with plan components, including desired conditions.

Forest-wide, suitable acres of the maximum amount of young growth that would be harvested in beach fringe, RMA, and OG LUD under any alternative comprise a very small component of the forest land within each of these plan components. Forest-wide maximum young-growth harvest would affect approximately 2.4 percent, 3.3 percent, 1.2 percent, and 0.4 of the forest land within the beach and estuary fringe under Alternatives 2, 3, 4, and 5, respectively. Likewise, Forest-wide maximum young-growth harvest would affect approximately 6.7 percent and less than 1 percent of the forest land within RMAs, outside of TTRA buffers, under Alternatives 2 and 5, respectively. Finally, under Alternatives 2, 3, and 5 the maximum amount of young-growth harvest in the Old-growth Habitat LUD would comprise approximately 3.3 percent, 2.8 percent, and 0.2 percent of the forest land (young-growth, POG, and unproductive forest) within the Old-growth Habitat LUD Forest-wide, respectively, and less than 1 percent of the forest land within other non-development LUDs (Alternatives 2 and 3 only). are about 2 percent, 4 percent, and 3 percent of the total acres in that component, respectively. Therefore, proposed modifications to contributing elements of the Conservation Strategy (e.g., beach and estuary fringe, RMAs, and non-development LUDs) under Alternatives 2, 3, 4, and 5 have the potential to result in localized, temporary reductions in the functioning of these elements (see response to CONS-1 and

CONS-2). That is, young-growth harvest may locally alter forest structure and reduce connectivity, but the beach and estuary fringe and RMAs would continue to function as intended across the planning area by serving as ecological transition zones, maintaining freshwater and marine aquatic and terrestrial habitat, and providing landscape connectivity. Additionally, as noted above, the transition to young-growth management would result in a significant reduction in the amount of projected old-growth harvest. Therefore, none of the alternatives would reduce the ability of the Conservation Strategy to maintain a functional and interconnected old-growth ecosystem across the planning area. When this is considered in conjunction with the plan components that are in place for young growth harvest in these areas (see CONS-1), any effects are anticipated to be localized and temporary.

Overall, the Conservation Strategy is functioning under conditions that are much better than anticipated at the time of its development. Actual and projected old-growth harvest levels under the current Forest Plan (Alternative 1) are far below levels predicted under the 1997 Forest Plan, which formed the context within which the Conservation Strategy was intended to function. Under the 1997 Forest Plan, it was projected that 84 percent of the original (1954) POG forest would remain in 100 years. Under the Proposed Forest Plan (Alternative 5) and the action alternatives, 91 percent of the original POG forest is anticipated to remain. This equates to approximately 400,000 acres of additional old-growth than were assumed during the development of the Conservation Strategy. These additional POG acres may function as additional reserves, enhance existing reserves, or increase the effectiveness of the matrix when located around harvest units. Moreover, with the Roadless Rule in effect, inventoried roadless areas (approximately 2,148,000 acres of development LUDs in roadless areas containing about 828,000 acres of POG) make an additional contribution to the maintenance of ecological function on the Tongass National Forest but do so outside of the elements of the Conservation Strategy. As such, the substantially greater presence of old-growth forest on the landscape across the planning area would outweigh the localize effects of young-growth harvest proposed in the Old-growth Habitat LUD, the beach and estuary fringe, and RMAs that would result under the action alternatives.

The Forest Service analyzed and disclosed the potential environmental consequences of young-growth harvest to contributing elements of the Conservation Strategy (e.g., beach and estuary fringe, RMAs, and non-development LUDs) under Alternatives 2, 3, 4, and 5 in the FEIS (See FEIS Chapter 3, Biodiversity section, Effects to the Old-Growth Forest Ecosystem). Appendix D of the FEIS also includes a section about the Integrity of the Conservation Strategy and discusses the ability of each alternative to maintain the integrity of the Conservation Strategy.

The proposed amendment retains the goal of providing an abundance and distribution of old-growth habitat to maintain viable populations of wildlife in the forest in its Wildlife Forest-Wide Standards and Guidelines, with plan direction to “Provide the abundance and distribution of habitat necessary to maintain viable populations of existing native and desirable non-native species well-distributed in the planning area (i.e., the Tongass National Forest).” (WILD1IIB, Proposed Forest Plan, p. 4-82).

See responses to PLR-2 and FEIS Appendix D.

COMMENT

CONS-4: The DEIS and Forest Plan lack detail on the harvest prescriptions for harvest in the beach fringe, Riparian Management Areas, and non-development LUDs. For example, the number of units, gaps between them, and the number of units in the specific area need to be explored and direction developed appropriately. We appreciate that the overarching LUD management goal and future desired conditions would define what is technically allowable and feasible in these areas, but there are few details as to how this will happen. The Forest Service should take steps towards figuring out how this is accomplished through pre-project planning with stakeholders and a clear process for reviewing projects to figure out how the goals were accomplished and what lessons were learned to ensure that these carry over to future projects. The Forest Service should also include direction in the Forest Plan to invest in scientific research to assess and monitor ecological conditions in the beach fringe, Riparian Management Areas, and non-development LUDs with the intention of strengthening management approaches and treatments.

RESPONSE

The Forest Plan includes plan components related to harvest of young growth in beach and estuary fringe, RMAs, and the Old-Growth Habitat LUD. The desired conditions, goals, objectives, standards, and guidelines work together, to provide overall direction and set sideboards for the project managers and resource specialists who will be implementing the Forest Plan. Management approaches add additional guidance by stating the intent of the plan components. Appendix D Table 2 contains a modeled estimate of harvest types by alternative for the beach, RMA, and Old-Growth Habitat LUD; specific stand prescriptions will be determined for each project based on site-specific information and are not included in the Forest Plan (see TIM-13). Appendix B contains a compatibility matrix for what harvest can be done in each LUD under each alternative: see Tables B-2.1 through B-2.5.

The plan monitoring program was revised to meet the 2012 Planning Rule requirements at 36 CFR 219.12 and is now a separate document, but part of the Forest Plan (http://www.fs.usda.gov/goto/Tongass/Monitoring). This document outlines what monitoring the Tongass plans to conduct. Monitoring must be within the technical and financial capabilities of the Forest. In addition to Forest-wide monitoring outlines in the plan monitoring program, project-level monitoring can also be done if recommended by the interdisciplinary team that evaluates the project and approved by the Responsible Official (decision-maker).

The Forest Plan is not the appropriate document to determine where money will be invested. Funding for Forest Service work comes through a variety of sources but is primarily allocated annually through Congress; this allocation is specific to a particular resource and cannot be used for other purposes. In addition, the National Forest System does not conduct independent research, although it can recommend projects and coordinate with its research branch, universities, and other interested partners. For example, there is currently ongoing research on a Tongass-Wide Young Growth Study to look at different treatment options in young growth and a cost share agreement with the State of Alaska for young growth inventory work.

See response to SPEC-42.

COMMENT

CONS-5: The amendment calls for the harvest of young-growth in beach buffers and key old growth habitat, however there is no mention of prioritizing certain places. The Forest Service should prioritize young-growth treatments to improve degraded habitats and improve deer numbers, especially in areas close to towns and villages to ensure subsistence opportunities are equal across the Tongass.

RESPONSE

The Forest Plan is a programmatic document that sets guidance for activities Forest-wide. Chapter 2 of the Forest Plan provides a forest-wide subsistence objective to “evaluate and consider the needs of subsistence users in making project land management decisions.”

Young-growth direction in Chapter 5 of the Forest Plan includes plan components and management approaches that are specific to young-growth management. The following management approach for young growth would allow for the consideration of other opportunities in the project area:

> “The intent is that during project planning, IDTs identify other resource opportunities in the project area, and if approved by the responsible official, integrate these opportunities into the project design. (See definition for Integrated Resource Management in Chapter 7.) When designing young-growth projects that would advance old-growth characteristics in the beach fringe, RMA, or old-growth reserve (OGR), IDTs seek out stakeholders to encourage creative and innovative approaches for developing silvicultural treatments that imitate the natural scale and distribution of disturbance patterns on the Tongass (e.g., wind-thrown timber that creates gaps and patches; landslides that create corridors and gaps; mortality that naturally thins stand).”

The Tongass Young Growth Strategy does outline some broad priorities and general options for young growth treatments across the Tongass. This type of priority setting is usually completed at the district or island level rather than at the Forest Plan level so that site-specific needs and information can be incorporated into the project, such as treatments that benefit local subsistence use patterns and winter habitat conditions.

See response to SUB-1.

COMMENT

CONS-6: The 1997 Forest Plan intended that early seral stands in non-development LUDs would be managed so that they develop into old-growth, but the Proposed Forest Plan dismisses these early seral stands as unimportant to the Conservation Strategy. Under Alternative 5, the Tongass Advisory Committee (TAC) recommended significant changes to the Tongass Conservation Strategy. Specifically, the preferred alternative calls for logging of young-growth stands in OGRs, Beach/Estuary Fringe Buffers, and Riparian Management Areas. This violates the intent of the original VPOP Strategy, and also stands at odds with the scientific underpinnings of the Conservation Strategy. Harvesting young-growth forest and building roads in buffers and reserves will seriously harm the Conservation Strategy. The DEIS states that "Continued inventories and monitoring of established nest protection buffers will help to inform future decisions," but there are no specifics on how this monitoring will be accomplished and what measures will be used to gauge continued success of the goshawk in heavily managed timber production areas. The Forest Service should leave intact beach- and estuarine-fringe forests, Riparian Management Areas, and OGRs. Allowing new clearcuts, of whatever size, in OGRs, beach buffers and Riparian Management Areas will reduce populations of goshawks and other forest-dwelling birds. These areas were set aside as reserves because they were considered critical to the long-term viability of many wildlife species across the forest.

RESPONSE

See also PLR-2, CONS-1, CONS-7, GOSH-2

Chapter 3 of the FEIS (Biodiversity section) states that "of the approximately 506,000 acres of young-growth forest on the Tongass National Forest, about 76 percent of young growth is older and in the stem exclusion stage. This type of stand condition has very low species diversity." The stem exclusion phase has little to no forage species important to deer and some small mammals, is often too dense to be used as foraging habitat for goshawks, and may not yet have large enough trees to be used for eagles to nest. These stands may be just reaching cone-bearing age so may also not be important for red squirrels. Treatment of these stands may open the canopy to allow more light to reach the forest floor which may assist in forage production; treatment can also be aimed at improving to tree spacing to increase growth. Each stand will be evaluated for treatment options by an interdisciplinary team of resource specialists. For example, a project evaluation can include consideration of existing and desired habitat conditions, adjacent landscape and habitat types, reserve connectivity, known wildlife usage in and near the project, insect and disease conditions, access and operability, and LUD. Young growth treatments in beach fringe, RMAs, and Old-Growth Habitat LUD should accelerate the stand toward old growth characteristics (desired conditions). Ten acre openings is the maximum allowed; it is not required to be that size. Openings may be less depending on stand size (cannot be over 35 percent of the stand) and the ability to achieve desired conditions. Management of young-growth stands through release, pre-commercial, and commercial thinning has the potential to increase biodiversity by concentrating growth in fewer, larger trees that, if allowed to grow over time, promote conditions that accelerate natural succession in order to achieve old-growth stand characteristics at a faster rate than would occur without treatment (Caouette et al. 2000; Carey 2003).

Alternative 3 and 4 consider allowing only commercial thinning in the beach fringe rather than a maximum 10 acre opening. Alternatives 3 and 4 also considered applying legacy standards and guidelines to young growth harvest. These are available options for the Responsible Official to choose for the decision.

The beach fringe and Old-Growth Habitat LUD discouraged road construction but it was allowed under some circumstances in the 2008 Forest Plan, as it would be under the proposed amendment. This amendment recognizes that some road construction or reconstruction may be required to access young growth for the transition; it includes a guideline (G-YG-WILD-01) to keep road construction to the minimum necessary in the Old-Growth Habitat LUD and a standard (S-TSC-WILD-01) to design and construct transportation system corridors to maintain wildlife habitat corridors between OGRs, RMAs, and beach fringe.

The intent of the Conservation Strategy was focused on the viability of old-growth associated/ dependent species and at that time no young growth management was foreseen in the life of the plan. Therefore, the intent was focused on old-growth and only precommercial treatments were envisioned for young-growth. Multiple criteria are considered during the design of old-growth reserves (see Appendix K), not just whether or not the reserve contains young growth or roads; Appendix K still allows for project-level review of reserves under this amendment. (See Young-growth Management Approach for Wildlife in Chapter 5 of the Forest Plan).

The created openings of up to 10-acres in the Old-growth Habitat LUD, beach buffers and RMAs was to provide more economical offerings to allow a more rapid transition to young-growth management. The TAC recommendation was to allow these openings to emulate the natural scale and distribution of disturbance patterns on the Tongass (e.g., wind-thrown timber that creates gaps and patches, landslides that create corridors and gaps, mortality that naturally thins stand, etc.) that correspond with silvicultural treatments. (See Young Growth Management Approaches in Chapter 5 of the Forest Plan.) While most natural disturbance results in openings are smaller than 10 acres, wind events and landslides have created this type of landscape. This type of management is limited to the first 15 years after plan approval and may result in up to 6,803 acres harvested across the Tongass within Old-growth Habitat LUD, beach buffers and RMA outside the TTRA buffer (FEIS Appendix D, Table 2). The 10-acre opening is a maximum and may be used in conjunction with thinning up to 35 percent of the stand. The shape and size of the clearcut could be designed to conform and blend with the landscape to minimize effects wildlife habitat. Forest Plan Standards (S-YG-BEACH-02, S-YG-RIP-02, S-YG-WILD-02) constrain young-growth harvest in these areas to a one-time only entry and to the first 15 years unless best available scientific information shows that additional entries are: a) warranted, and b) meet the LUD objectives. Every project and activity must be consistent with the applicable plan components, including the desired conditions. (36 CFR 219.15(d))

COMMENT

CONS-7: Concentrating logging on small isolated portions of the Tongass exacerbates an already troubling situation and compromises the Conservation Strategy. These areas are of critical importance to several old-growth dependent species. According to the DEIS, the vast majority of the stands in the Tongass result in negative stumpage value and the isolated areas that reflect positive stumpage values are located in a very concentrated portion of the Tongass. The DEIS never discloses the average stumpage values across the Tongass or the location of the only stands that appraise positively. The analysis also does not appear in the planning record.

RESPONSE

In order to transition to primarily young growth harvest, it is necessary to enter the same areas that old-growth harvest has occurred in the past because that is where the young growth and associated infrastructure are located. Many of the oldest young growth stands that will be ready for commercial harvest over the next 15 years have received no intermediate treatments, are in a stem exclusion phase, and were logged prior to current standards and guidelines so may occur in more sensitive areas than would be allowed under the 2008 Forest Plan direction. Most of the younger young growth stands (those less than 25 years) have received some precommercial thinning treatment; important deer forage may persist for longer in these areas and the trees may grow faster, delaying the onset of stem exclusion. Young growth could also receive additional intermediate treatments.

Some areas of the Forest are important to both wildlife and timber harvest, such as Prince of Wales Island. Viability analyses that occurred leading up to the 1997 Forest Plan acknowledged that there could

be gaps in distribution of some species but that overall viability could be maintained across the Forest. It is possible that Prince of Wales is a location where some species are not contiguous across the entire island (i.e., gaps exist). The Conservation Strategy protects a series of large, medium, and small old-growth habitat reserves (including non-development LUDs) as well as standards and guidelines for matrix management. Although the amendment would include harvest of young growth in some Conservation Strategy elements such as beach fringe, Riparian Management Areas, and Old-Growth Habitat LUDs, the range of alternatives includes varying levels of protection of these areas through new young growth plan direction, but no old growth harvest would be allowed in these areas under any alternative.

The suitable land base where timber harvest can occur has continually decreased over the years. The latest reductions in this suitable land base are within the Inventoried Roadless Areas. The Preferred Alternative (Alternative 5) also proposes no old-growth harvest outside the Phase 1 lands as identified by the decision on the 2008 Forest Plan Amendment (ROD pp. 64 to 66) or within T77 watersheds and The Nature Conservancy /Audubon Priority Conservation Priority Areas (See Forest Plan Appendix A).

By restricting this land base, the timber harvest becomes more concentrated into small areas. It is also true that the economics of timber harvest tend to concentrate harvest. The Forest Service is required to issue only positive sales, but specific locations of these are not known until project-level analyses are conducted. However, on the other hand, more and larger areas will not have any old-growth timber harvest and will maintain the old-growth characteristics and contribute to maintaining the integrity of the Tongass Conservation Strategy. This is a trade-off for resources that should provide both habitat for old-growth associated and dependent species and a timber base for commercial timber harvest.

In order to transition in 10-15 years as outlined in the Secretary's Memo and brought forward in the Purpose and Need, all young-growth lands were considered. Since the age of the young-growth stands is a limiting factor, the oldest stands of young growth are being considered for harvest to facilitate the transition. If the oldest young-growth stands are not included in the earliest phase of the transition, it is highly unlikely the Forest Service could meet the Purpose and Need of the amendment. Therefore, old-growth timber harvest would continue for a longer time period. If young-growth harvest is not allowed in the most areas, opportunities to improve habitat conditions for wildlife and fish and stand function in places that would potentially benefit from restoration work and advancement of seral stages toward old-growth conditions, would be lost.

An updated productive old-growth analysis including a high volume productive old-growth and a large tree productive old-growth analysis has been provided in the Forest Plan Amendment FEIS (Chapter 3, Biodiversity section).

An updated financial analysis is provided in the Forest Plan Amendment FEIS (Chapter 3, Economics section) and includes the net revenues or stumpage values (see Table 3.22-16). Viewed over 15-year and 100-year planning horizons, all five alternatives would result in positive net revenues (stumpage values). Alternatives 1, 4, and 5 also would result in positive net revenues over the 25-year planning period; Alternatives 2 and 3 would result in negative net revenues for the 25-year period. FEIS Appendix B describes and documents the analytical processes and models used for the 2016 Forest Plan Amendment FEIS.

COMMENT

CONS-8: Forest Service must examine the adverse effects of second-growth logging on the overall Conservation Strategy because not all second-growth stands have the same ecological value.

RESPONSE

Not all young-growth stands have the same habitat value. Young-growth stands that have reached the stem exclusion stage may not be fully functioning in terms of habitat value; these stands could benefit from treatment such as those proposed during this amendment.

FEIS Appendix D describes the effects to the Conservation Strategy of logging young growth in beach buffers, RMAs, and Old-Growth Habitat LUDs. Chapter 5 of the Forest Plan contains several plan

components related to young growth management in these contributing elements to the Conservation Strategy, including desired conditions to accelerate old-growth characteristics in those stands. Each project implemented under the Forest Plan will evaluate site-specific conditions and resource concerns to determine whether, how, and when to log young-growth stands. Part of that analysis by the interdisciplinary team should include looking at where on the landscape stands proposed for harvest occur, the current condition of those stands, and the harvest prescription to advance those stands toward the desired condition. Landscape connectivity would also be reviewed (See WILD1.VI.A, page 4-86 of the Forest Plan.) Every project and activity must be consistent with the applicable plan components (36 CFR 219.15(d)).

See response to PLR-2 and FEIS Appendix D.

COMMENT

CONS-9: Changes to the Tongass Conservation Strategy and transportation management in the Proposed Forest Plan are significant enough to require a plan revision. The NFMA requires land management plans to be revised at least every 15 years, or sooner if physical conditions or demands on the land and resources have changed sufficiently to affect overall goals or uses for the entire unit.

RESPONSE

Effects to the Tongass Conservation Strategy from proposed changes to the Forest Plan have been evaluated and discussed in Appendix D of the Forest plan Amendment FEIS concluding that the integrity of the Conservation Strategy is maintained under all alternatives. This Strategy was designed to provide habitat for old-growth associated and dependent species. Since the proposed action alternatives target a more rapid transition to young growth harvest, there would be a corresponding lower amount harvest of old-growth harvest to meet demand . As noted under CONS-3, the Conservation Strategy is functioning under conditions that are much better than anticipated at the time of its development in 1997. Actual and projected old-growth harvest levels under the current Forest Plan (Alternative 1) are far below levels predicted under the 1997 Forest Plan, which formed the context within which the Conservation Strategy was intended to function

Some young-growth harvest is proposed in the beach buffer, Riparian Management Areas and the Old-growth Habitat LUD. However, constraints are in place to limit the size of the openings and the level of thinning. See young growth direction in Chapter 5 of the Forest Plan and response to CONS-1. Forest Plan Standards (S-YG-BEACH-02, S-YG-RIP-02, S-YG-WILD-02) constrain young-growth harvest in these areas to a one-time only entry and to the first 15 years unless best available scientific information shows that additional entries are: a) warranted, and b) meet the LUD objectives. Every project and activity must be consistent with the applicable plan components, including the desired conditions. (36 CFR 219.15(d)). The desired conditions in these areas is to mantain connectivity for wildlife and to accelerate old-growth conditions.

See response to PLR-1 and CONS-3.

COMMENT

CONS-10: The Forest Service should clarify old-growth habitat reserve modification procedures for small OGRs to require comparable conservation value (see Appendix D of the 2008 Plan) and modify Chapter 3, Old-Growth LUD, WILD1 to read “”Alternative reserves must provide comparable achievement of the Old- growth Habitat LUD goals and objectives within each VCU.

RESPONSE

The responsible official has the discretion to determine whether and how to amend the plan. See 36 CFR 219.13.a and FSH 1909.12, Chapter 20, Section 21.3. For this amendment, the scope is focuses on making changes primarily to facilitate a transition to primarily young growth harvest in about a 15 year timeframe and on making separate renewable energy and transportation systems corridors plan components (to replace the TUS overlay). Modifying criteria for small OGRs, which are part of the

Conservation Strategy, is outside of the scope of this focused amendment. Many of the recommendations from the 5-year review were not incorporated into this amendment.

OGR modification procedures are outlined in Appendix K of the forest plan (now with clarifications for young-growth harvest in the Old-growth Habitat LUD). At the project level, proposed OGR modifications would be required to provide comparable achievement of Old-growth Habitat LUD goals and objectives compared to the original OGRs.

Plan components are considered together and interact to form the overall direction; every project decision must describe how the project is consistent with plan components, including meeting the desired condition of the LUD.

COMMENT

CONS-11: Large forest openings and extensive timber thinning without appropriate slash treatments can interfere with animal movements and increase vulnerability of some species to predation, harvest by humans, and/or exposure to deep snow and severe weather. The selected alternative should limit young-growth treatments to actions that maintain or improve wildlife habitat in beach and estuary fringe forest. These actions should include: openings that are limited to two acres or less in order to maintain hunting habitat for goshawks and provide thermal cover for deer; slash that is treated to allow unconstrained movement of deer, bears, wolves, and other species; and openings in the beach fringe that maintain a corridor of mature or old forest that is no less than 660 feet wide to maintain effective thermal cover (Concannon 1995).

RESPONSE

See CONS-3, CONS-4, CONS-6, CONS-12, and SPEC-6.

Plan components are considered together and interact to form the overall direction; every project decision must describe how the project is consistent with plan components, including meeting the desired condition. For beach and estuary fringe, those desired conditions include providing habitat and connectivity and accelerating the development of old-growth characteristics (DC-YG-BEACH-01).

Management approaches are used to guide project implementation of the Forest Plan components (desired conditions, objectives, standards, guidelines, suitability of lands, and goals if stated); they relate to the desired conditions and describe the principal strategies and program priorities the Responsible Official intends to use to carry out projects. The Forest Plan includes an intent statement for young growth harvest prescriptions and opening sizes in the beach and estuary fringe to consider spatial and temporal conditions of the adjacent landscape, and intends for treatments to facilitate a more rapid recovery of late successional forest characteristics. (See management approaches for beach and estuary fringe in Chapter 5 of the Forest Plan.)

The recommendation from the Tongass Advisory Committee represented in Alternative 5 is that any created opening size must not exceed 10 acres or to thin the stand in no more than 35 percent of the stand's basal area. Site-specific openings determined at the project level will vary in size and shape. Alternatives 3 and 4 considered only commercial thinning in the beach fringe rather than a maximum 10 acre opening. Alternatives 3 and 4 also considered applying legacy standards and guidelines to young growth harvest (see Appendix F of the FEIS). These are available options for the Responsible Official to choose for the decision. No old-growth harvest is planned under any alternative in the beach and estuary fringe, Riparian Management Area, or Old-Growth Habitat LUD.

Recent studies of slash treatment, such as Module IV of the Tongass-wide Young Growth Study and observation of commercial thinning of ongoing commercial young-growth sales and older young-growth treatments, will be used to determine which slash method is included in the silvicultural prescription to meet resource objectives. Specific harvest prescriptions and slash treatment will be determined at the project level to consider site specific conditions (see TIM2, WILD2). Silvicultural prescriptions are determined at the project level (see TIM2). The recommended slash treatment may depend on the silvicultural prescription used, the density of the existing stand, utilization specifications, and the location

of the treated stand on the landscape. Landscape connectivity will also be evaluated at the project level (WILD1.VI).

COMMENT

CONS-12: Young-growth treatments in the Old-growth Habitat LUD should be designed to accelerate development of old-growth characteristics without compromising landscape connectivity and animal movement.

RESPONSE

See responses to TIM-13, CONS-1, and SPEC-6.

The Old-Growth Habitat LUD does play an important role in the Conservation Strategy. In some instances, young-growth stands within the boundary of this LUD are not fully functioning for wildlife needs. Individual stand treatments will be determined at the project level. Plan components are considered together and interact to form the overall direction; every project decision must describe how the project is consistent with plan components, including meeting the desired condition. For Old-Growth Habitat LUD, those desired conditions include maintaining habitat and connectivity and accelerating the development of old-growth characteristics (DC-YG-WILD-01) and treating young-growth to emulate the natural scale and distribution of disturbance patterns (DC-YG-WILD-02).

Management approaches are used to guide project implementation of the Forest Plan components (desired conditions, objectives, standards, guidelines, suitability of lands, and goals if stated); they relate to the desired conditions and describe the principal strategies and program priorities the Responsible Official intends to use to carry out projects. The Forest Plan includes an intent statement for Old-Growth Habitat LUD harvest prescriptions and opening sizes to consider spatial and temporal conditions of the adjacent landscape; intends for treatments to facilitate a more rapid recovery of late successional forest characteristics; and allows for an Old-Growth Habitat LUD to be modified to exclude young-growth proposed for harvest if a net gain in old-growth can be achieved and Forest Plan Appendix K criteria can be met (see management prescriptions).

COMMENT

CONS-13: The Forest Service's refusal to undertake a comprehensive review of the Conservation Strategy—its scientific underpinnings, its overall validity, and its species-specific validity - along with the 2016 amendments, is arbitrary, capricious, and contrary to NEPA, NFMA, and the 1982 Rule.

RESPONSE

See responses to PLR-1, and PLR-2, CONS-1, and Appendix D of the FEIS.

COMMENT

CONS-14: The Forest Service must re-evaluate the integrity of the Conservation Strategy to bring the plan into compliance with the 1982 Rule.

RESPONSE

See response to PLR-1, PLR-2, CONS-1, and Appendix D in the FEIS.

COMMENT

CONS-15: The changes proposed by the 2016 Forest Plan Amendments cannot be reconciled with the Conservation Strategy, and therefore are inconsistent with the 1982 rule.

RESPONSE

See responses to PLR-1, PLR-2, and CONS-1 and Appendix D in the FEIS.

COMMENT

CONS-16: The analysis of impacts to the Conservation Strategy was deferred to project-level decisions, and this approach is not reasonable for three reasons: 1) the agency has a duty at the programmatic stage of analysis, where it is required analyze the cumulative effects of localized impacts across a broader landscape; 2) there is precedent for the agency manipulating the elements of the Conservation Strategy to effectuate timber harvest goals, at the expense of other resources considerations; and 3) there is a significant risk that this approach will lead to significant impacts escaping meaningful review when tiering and site-specific projects will not be given the full level of environmental review required by NEPA.

RESPONSE

See also PLR-2 and Appendix D.

The proposed Forest Plan does not change the old growth Conservation Strategy, although effects to elements of the Conservation Strategy may occur (see Appendix D). The FEIS and Appendix D analyzed possible impacts to the Conservation Strategy of the proposed Forest Plan and concluded that the integrity of the Conservation Strategy is maintained. Estimated young growth harvest within the beach and estuary fringe over 100 years would range from only 0.4 percent of the total forested beach and estuary fringe acres for the preferred alternative (Alternative 5) to 3.3 percent for Alternative 3. For RMAs, the preferred alternative would harvest an estimated 0.3 percent of the total forested habitat in RMAs over 100 years, while the other alternatives would harvest between 0 and 6.7 percent. Estimated young growth harvest within the Old-growth Habitat LUD for the preferred alternative is 0.2 percent of the total forest land area within the Old-growth Habitat LUD, while the other alternatives would harvest an estimated 0 to 3.3 percent over 100 years. At the project level, the interagency review process outlined in Appendix K can be used to modify an Old-growth Habitat LUD with proposed young-growth harvest so this number could be lower once the site-specific project review and decision are implemented.

The Forest Plan is programmatic and provides overall direction for projects implemented under the plan. The FEIS and Appendix D did not defer the effects analysis of the Conservation Strategy to the project level but acknowledged that additional site specific analysis occurs at the project level. The sideboards set in the Forest Plan by lands suited for timber production, standards and guidelines, and other plan components and content were used to evaluate the expected outcomes at the Forest Plan level, but because individual projects and activities are not yet proposed, site specific information is not available for the programmatic review. Thus, additional analysis occurs at the project level to include any localized resource effects and to ensure the project implements the relevant Forest Plan requirements, such as the landscape connectivity standard and guideline (WILD1.VI.A). The DEIS looked at the Conservation Strategy from overall integrity of the strategy; cumulative effects during project analysis look at past, present, and reasonably foreseeable projects in the analysis area to further ensure the Conservation Strategy is maintained during project implementation.

The FEIS version of Appendix D has been expanded and an evaluation of the integrity of the Conservation Strategy under the no action and action alternatives is presented. The conclusion is that the integrity of the Strategy would be maintained under any of the alternatives. We believe the documentation for this conclusion is clearly presented.

COMMENT

CONS-17: Some old-growth reserves (OGRs) were included in the conveyance of the nearly 70,000 acres of NFS land in the Tongass to Sealaska under the National Defense Authorization Act for Fiscal Year 2015 (Public Law 113-291). These circumstances require a re-evaluation of the entire network of OGRs on northern Kuiu Island and on Prince of Wales Island and its adjacent islands because the function of some other OGRs and matrix lands may be affected by nearby transfer lands that can be expected to logged more intensively than anticipated under the prior federal ownership. This re-evaluation is necessary to ensure the integrity of the Conservation Strategy as a whole in those areas.

RESPONSE

FEIS Appendix E explains the modifications made to the small OGRs on Prince of Wales Island. These modifications were done by interagency biologists from US Fish and Wildlife Service, State of Alaska Department of Fish and Game and US Forest Service and represent the biologically preferred alternative. No OGRs were affected on Kuiu Island or elsewhere. No effort was made during these modifications to avoid higher productive forested lands to allow for more intensive management. The evaluation of these modifications followed the Forest Plan, Appendix K direction. Both the Appendix K criteria and the Appendix D criteria plus an evaluation of low elevation Productive Old-growth (POG) were used in evaluation. Also the small OGRs were examined to see if they still provided connectivity as the previous design did. As currently done at the project level, the old-growth matrix lands as they relate to connectivity will be further examined at the project level to disclose the effects.

The tables in the FEIS Appendix E evaluate the pre-conveyance, post-conveyance and the interagency' s biologically preferred OGR designs using the Forest Plan Appendix K and FEIS appendix D criteria. In some cases, the post-conveyance design still meets the OGR design criteria and the biologically preferred design is identical. No other designs were proposed to balance other resource considerations (Forest Plan Appendix K, p. K-2.)

This approach does not preclude that further analysis may occur during project-level analysis. One of the TAC's recommendations was to "The USFS should prioritize utilizing OGR modification processes to capture …additional young growth acres within OGRs, putting particular emphasis on adjacent landscapes, where a net gain of productive old growth habitat is possible, while maintaining and enhancing landscape connectivity."

Public Law 113-291 also amended ANILCA, Section 508, to include 152,000 acres of LUD II Conservation Areas. These areas primarily focused on protecting old-growth forest. A LUD II is a Congressionally-designated land allocation and the Land Use Designation cannot be changed except by an act of Congress. More than 31,000 of these areas were previously allocated to Development LUDs and now contribute to the Conservation Strategy.

COMMENT

CONS-18: There should be a provision and standards and guidelines prescribing that, during the OGR modification process, there should be no net loss of protected POG across the Forest.

RESPONSE

The Forest Plan includes a young-growth management approach for wildlife for adjusting OGRs if young-growth harvest is proposed within the current boundaries. The intent is that an "exchange" of young growth and old growth could be made – where the boundary of the reserve is adjusted to remove young growth and add an equivalent acreage of productive old growth. The objective of this direction would be to achieve a net increase in productive old growth acres, whenever possible. When applied at the project level, this would lead to an increase of productive old growth in the reserve network.

COMMENT

CONS-19: Forest Service should use science review process to assess the new and modified OGRs before issuing the FEIS. If the review of the modified OGRs indicates they are unlikely to meet the reserve system intent, especially in heavily-logged areas, and more old-growth logging occurs on nearby USFS land, the opportunity to create a more effective system in those areas may be lost.

RESPONSE

The reserve system has to be only on NFS lands where the USFS has jurisdiction for management of those lands. The interagency team has recommended modifications to the reserves to best meet the criteria for such reserves on remaining NFS lands adjacent to the transferred lands. The interagency recommendations for the modified reserves are included in all action alternatives. Project level reviews of old growth reserves can also occur if the interdisciplinary resource team identifies a concern about the

location or functionality of a reserve within the project area. In addition, if young growth harvest is proposed within Old-Growth Habitat LUD, an interagency team can recommend modifying the boundary to exclude young growth if additional old growth can be included for a net increase of old growth within the reserve.

Appendix K of the Forest Plan provides the procedures for modifying old-growth habitat reserves. These procedures were followed; they do not include a Science Review.

COMMENT

CONS-20: Alternative 5 should be rejected because it increases the number of watersheds that would exceed a road density greater than 1 mile / square mile by 20 percent.

RESPONSE

The Watershed Condition Framework (USDA Forest Service 2011) concluded that a watershed with a road density of less than 1 mile / square mile is considered "properly functioning." Table 3.4-5 in the DEIS indicates that currently 9.6 percent of 6th field subwatersheds exceed 1 mile / square mile road density and Alternative 5 would take that to 11.0 percent after 100 years of implementation on NFS lands. This would leave 89 percent of the watersheds on the Tongass National Forest with less than 1 mile / square mile of road after 100 years of assumed maximum harvest and road building allowed under the Forest Plan. Across all NFS lands on the Tongass, this is an average of 0.23 mile / square mile road density. When all ownerships are considered (Table 3.4-13 in the DEIS), 19.8 percent of watersheds would exceed 1 mile / square mile after 100 years of full implementation under Alternative 5, which leaves over 80 percent of the watersheds in Southeast Alaska in a properly functioning condition, and an overall average of 0.45 miles / square mile.

COMMENT

CONS-21. The EIS should include the most recent inventory of global temperate rainforest and evaluate the importance of the Tongass' intactness (DellaSalla et al 2011).

RESPONSE

This reference has been added in the FEIS.

COMMENT

CONS-22. The EIS should include an old-growth analysis by watershed.

RESPONSE

See FEIS Chapter 3, Biodiversity section. In Chapter 3, Tables 3.9-12 through 3.9-14 present the estimated percent of original productive old-growth (POG), original high-volume POG, and original large-tree POG remaining after 100 years by biogeographic province and alternative. In addition, Table 3.9-15 presents the number and acreage of intact large watersheds under existing condition and after 100 years by biogeographic province and alternative. These tables demonstrate the percentage of old growth in these various categories that will be preserved. Tongass old growth is defined as stands with trees at least 250 years of age. Also see FEIS Appendix D.

Young Growth in Audubon/TNC and T77 Watersheds (YGAT)

COMMENT

YGAT-1: The Forest Plan lacks substantive requirement to reduce or mitigate potential impacts from young-growth timber sales in these watersheds.

RESPONSE

The Forest Service may apply project-specific mitigation to reduce effects to fish and wildlife habitat, or elect to apply the 'no net loss" concept outlined in the TAC overarching principals. These measures are determined based on the specific conditions of planned and proposed sales following project-specific analysis by an interdisciplinary team. For all land-disturbing activities, BMPs from the National Core BMP Technical Guide FS-990a are applied to maintain the chemical, physical, and biological integrity of the Nation's waters. Applicable BMPs are also found in the Alaska Region Soil and Water Conservation Handbook, FSH 2509.22. Plan components from Chapters 3, 4, and 5 also apply.

COMMENT

YGAT-2: The Forest Service should recognize the exceptional fish and wildlife values of the T77 watersheds and TNC/Audubon conservation priority areas. Some recommend that they be remove from the suitable timber base altogether. The Forest Service should preserve these watersheds and make production of wild salmon, trout and steelhead their highest management priority.

RESPONSE

The Forest Service recognizes the exceptional fish and wildlife values of the T77 watersheds. These watersheds, along with watersheds in LUD II status are considered the pillar of commercial, sport, and subsistence wild salmon harvest in the region and provide a large contribution to the southeast Alaska economy. Alternative 5 identified old-growth stands within the T77 watersheds as not suitable for timber production, except for small sales after the transition is complete. If young-growth harvest is not allowed to be harvested in these watersheds, opportunities to improve habitat conditions for wildlife and fish and stand function in places that would potentially benefit from restoration work and advancement of seral stages toward old-growth conditions, would be lost.

Further, in order to transition in 10-15 years as outlined in the Secretary's Memo and brought forward in the Purpose and Need, all young-growth lands were considered. Since the age of the young-growth stands is a limiting factor, the oldest stands of young growth are being considered for harvest to facilitate the transition. If the oldest young-growth stands are not included in the earliest phase of the transition, it is highly unlikely we could meet the Purpose and Need of the amendment. Under Alternative 5, the lands inside T77 watersheds and TNC/Audubon conservation priority areas, include almost 17,000 acres of suitable young-growth that would be at least 60 years old by the end of the 15-year transition period. The Tongass Advisory Committee recognized this need to facilitate the transition, and recommended that these areas be identified as suitable for young-growth timber production.

COMMENT

YGAT-3: Should have a more Rigorous Scientific Review of Projects likely to be implemented in certain High-value Watersheds.

RESPONSE

Language in Chapter 5 of the forest plan has been edited to better reflect the intent of the TAC recommendations for the "high-value fish watersheds". Alternative 5 now includes Management Approach language explaining the agency's intent to conduct an internal scientific review with stakeholders to determine likely impact to fish and wildlife habitat from proposed young-growth timber projects that intersect with the "high-value fish watersheds" identified in Appendix B of the Final TAC

Recommendations (Forest Plan Appendix B). Project-specific analysis by an interdisciplinary team will determine if additional mitigation measures are needed.

See response to comment SPEC-39.

COMMENT

YGAT-4: Forest Service should clarify that all old-growth stands in the T77 watersheds and TNC/Audubon conservation priority areas will be protected and removed from the suitable timber base as recommended by TAC.

RESPONSE

Forest Plan Appendix B has been updated to reflect the Final Tongass Advisory Committee (TAC) recommendations. We believe that the term used on p. 13 of the final TAC recommendations – TNC/Audubon conservation priority areas – means the same as what is stated in the text on page 38 of the TAC recommendations - TNC/Audubon Core Conservation Areas. Unfortunately, these terms are a bit confusing but they both together comprise the Conservation Priority Watersheds. During the drafting of the Proposed Forest Plan, the TAC provided the Forest Service a map (project record 769_05_000771), and the legend term on that map - Conservation Priority Watersheds - includes two categories: Core Areas of Biological Value and High Value Watersheds (dark green and light green, respectively). This is what was used to identify the TNC/Audubon conservation priority areas in the analysis.

Proposed LUD changes common to the action alternatives are described in Chapter 2 of the FEIS. No other LUD changes have been made to incorporate lands not suited for timber production into the natural setting LUDs. Old-growth harvest from T77 watersheds and TNC/Audubon conservation priority areas is excluded under Alternative 5. (See FEIS Chapter 2, Alternative 5 description and Forest Plan Appendix A.) This was not clear in the DEIS and the suitability map did not show that all of these areas had been removed. The map for Alternative 5 in the FEIS clearly shows that they have been removed from the old-growth suitable base.

COMMENT

YGAT-5: The Forest Service should set up a phased approach for young-growth logging and create two phases, similar to the approach used in the 2008 Plan. Doing so would ensure that TNC/Audubon conservation priority areas could be set aside into Phase 2 for young-growth harvesting, while all other young-growth lands would be in Phase 1.

RESPONSE

In order to meet the timeline for the young growth transition as outlined in the Undersecretary's memo, all young growth lands were considered. Since the age of the young growth stands is a limiting factor, the oldest stands of young growth are being considered for harvest to facilitate the transition. If the oldest young growth stands are not included in the earliest phase of the transition, it is highly unlikely we could meet the purpose and need of the amendment.

Forest Plan Appendix B has been updated to reflect the Final Tongass Advisory Committee (TAC) recommendations regarding. TNC/Audubon conservation priority areas are discussed in Chapter 2 of the FEIS under Alternative 5, and also in Forest Plan Appendix A.

COMMENT

YGAT-6: The Forest Service should not preclude any timber harvest in the T77 watersheds. There are already too many restrictions affecting communities.

RESPONSE

Alternatives 1 through 4 considered this option.

Best Available or Relevant Science (BAS)

COMMENT

BAS-1: The Forest Service should comply with NFMA's regulatory requirements to base its decision on the best available science.

RESPONSE

The interdisciplinary team has used the best available scientific information to amend the plan and to modify the plan monitoring program to meet the requirements of the 2012 Planning Rule (36 CFR 219.12(c)). The responsible official will document how the best available scientific information was used to inform the plan decision. The record of decision (ROD) for the plan amendment will include documentation of how the best available scientific information was used to inform planning, the plan components, and other plan content, including the plan monitoring program. Further, numerous refinements and updates were made to the EIS between the DEIS and FEIS (e.g., climate change assessment, Conservation Strategy assessment).

In regards to the Tongass Old-growth Habitat Conservation Strategy, recent advancements in the fields of conservation science and landscape ecology and new knowledge of individual species' biological needs are discussed throughout the Wildlife and Biodiversity sections of the EIS, as well as in Appendix D. Many of these topics, including the importance of strong connections between aquatic and terrestrial ecosystems and upstream and downstream linkages within stream and river systems, the contribution of matrix lands to conservation, and the range of ecological functions provided by young-growth stands were identified during the original development of the Conservation Strategy for the 1997 Forest Plan and considered again during the Interagency Forest Plan Conservation Strategy Review (USDA Forest Service 2007) conducted for the 2008 Forest Plan Amendment. Appendix D of the EIS touches on some of the new science related these topic areas relevant to conservation planning on the Tongass National Forest. Information from these studies, other relevant studies and other best available science would be used to review the Conservation Strategy design if in the future, data from various sources suggest that the Conservation Strategy is no longer functioning as originally intended. However the results of the analysis in Appendix D indicate the Conservation Strategy currently functions as intended and is expected to function regardless of which alternative is selected.

COMMENT

BAS-2: The DEIS Fails to Include or Address Relevant Science.

RESPONSE

See response to BAS-1.

Air Quality (AIR)

COMMENT

AIR-1: The DEIS should evaluate health risks associated with increased utilization of biomass for energy and heat stating that NEPA requires the Forest Service to consider the health effects of federal actions. [40 C.F.R. § 1508.8]. The reason for this request was due to a citation presented stating that "[b]urning biomass could lead to significant increases in emissions of nitrogen oxides, particulate matter and sulfur dioxide and have severe impacts on the health of children, older adults, and people with lung diseases." [Exh. 50 at 5 (Vick 2011)]. Despite federal directives, the DEIS never addressed the issue of air pollution caused by wood combustion and concludes that the analysis of air quality effects in the DEIS is conclusory, misleading and fails to consider the adverse health impacts caused by wood combustion. The USFS should explain the linkage between Juneau's past exceedance in National Ambient Air Quality Standards (NAAQS) to wood combustion. And to address why the USFS concludes that the greatest risk to air quality in the region arises from cruise ship emissions in Wilderness. Additionally, scoping comments requested that the DEIS review public safety concerns with biomass combustion facilities and disclose the risk of explosions to the public.

RESPONSE

Comments suggest that disclosure of the risks to human health caused by pollutants, in particular those created by the combustion of wood projects (biomass burning or other wood burning in wood stoves) be presented more clearly. Comments also suggest the specific causes attributed to the 1990's exceedance of National Ambient Air Quality Standards in the city of Juneau be disclosed. Comments also suggest that the analysis in the DEIS inadequately evaluates the effects of air pollution on Tongass resources, in particular human health and provide some citations for us to review and consider in our analysis.

This amendment is not focused on biomass. Some portion of the harvested timber may be used in energy production as biomass but the amount and timing of such use is uncertain. Therefore, the consequences of harvesting as biomass is not a focus of the analysis. Discussion of biomass and its production of particulate and other air pollutants are identified in the FEIS Chapter 3 Air section.

Biomass boiler facilities in schools, hospitals, health clinics and office buildings, proposed in any plan by the USDA Forest Service would be required to undergo project-level NEPA analysis, which indeed would evaluate the risks to human health as a possible consequence of these types of actions. The Forest Plan Amendment, however, is not a focused project plan on biomass facilities or any other specific renewable energy proposal. The Plan Amendment provides for opportunities for any proponent of renewable energy, including the development of biomass facilities, to consider such actions through additional project-level NEPA.

With regard to the causation of exceeded the NAAQS which occurred in the Juneau area during 1990-97, the EIS indicates that the sources of pollutants are probably local and anthropogenic (Dillman et al. 2007) (see page 3-19). The exact sources of these air pollutants is uncertain since the Forest Service has no jurisdiction for monitoring on non-NFS lands. The EPA through ADEC issues air permits to industrial sources that demonstrate compliance with the Alaska Ambient Air Quality Standards, which are identical to the National Ambient Air Quality Standards (NAAQS). The primary standards were developed to protect public human health and the secondary standards to protect public welfare. Linking pollutants to specific sources would be speculative on our part; however possible sources for particulates are described in Dillman et al. (2007). Because we currently do not have an abundance of biomass boiler facilities on the Tongass N.F. they currently are considered to provide low levels of particulate into the atmosphere and are not currently contributing to levels of air pollution that would trigger exceeding NAAQS. The discussion in Chapter 3.1 concerning air pollution sources discusses cruise ship emissions in Wilderness as one of the greatest contributors to particulate into the atmosphere which currently has the greatest risk to air quality in the region. When and if biomass facilities or other additional uses of biomass are proposed on National Forest System Lands, the sources and its affects will be properly analyzed through project-specific NEPA.

The Forest Service does acknowledging that an increase in wood burning could adversely impact air quality, but has not quantitatively analyzed those impacts. Because this amendment does not propose any specific biomass or wood-burning energy development, we have no specific parameters to evaluate for any of the alternatives. EPA and ADEC have regulatory responsibility, under the Clean Air Act, for air quality related to these kinds of sources. The enforcement of the applicable regulations by these agencies is anticipated to keep any potential adverse effects within the standards for air quality; therefore we conclude that no significant indirect effects from the uses of the Tongass National Forest should occur.

Geology/Soils and Physical Setting (SOIL)

COMMENT

SOIL-1: The EIS incorrectly describes the history of Glaciation of Tongass.

RESPONSE

This section of the EIS was intended to tell the reader that the long history of glaciation shaped the landscape of Southeast Alaska. We agree that the data presented in this paragraph misses an important point, namely that by about 13,500 years ago much of southeast Alaska was ice free (Geology section, page 3-25 in the DEIS). This particular paragraph of the introduction has been in the Forest plan EIS since 1997 and was not updated for the amendment. The statement was not an “effort to halt responsible development and utilization of the forest”. A sentence has been added to this paragraph in the FEIS to clarify that by about 13,500 years ago much of Southeast Alaska was ice free.

Streams and Watersheds (S&W)

COMMENT

S&W-1: Stream surveys are inadequate and critical information concerning the stream miles by class in the whole forest is not presented. These gaps—and the failure to acknowledge or analyze them— have the result that the DEIS understates the likely effects of logging and roadbuilding on aquatic habitat.

RESPONSE

The DEIS (and FEIS) discloses that streams may be missing from the corporate layer at the forest level. During project planning, field surveys are conducted to add and correct streams to support effects analysis and ensure stream protection during project implementation according to Forest Plan standards and guidelines. Field efforts place high priority on areas with high probability of unmapped fish streams. Standard field procedures are followed (USDA Forest Service 2015c).

During project planning, field surveys are conducted to add and correct streams to support effects analysis and ensure stream protection during project implementation according to Forest Plan standards and guidelines. Field efforts place high priority on areas with high probability of unmapped fish streams. Standard field procedures are followed (USDA Forest Service 2015c). Decisions at the project level will consider the additional streams and effects. Text was added to the water section to clarify the meaning of the percent water bodies in watersheds within 300 feet of roads and the footnote on Table 3.4-1 has been revised to state that additional unmapped streams are present, as opposed to unmappable.

COMMENT

S&W-2: The DEIS presents a misleading picture of current watershed condition in areas impacted by logging.

RESPONSE

Text additions were added in the FEIS to clarify status of watersheds and the source of that information. Additional details for each watershed are available in the project record and on an interactive map available to the public at http://apps.fs.fed.us/nfs/nrm/wcatt/WCFMapviewer/

Effects to specific watersheds proposed to be harvested in the future, including young-growth harvest in RMAs outside of TTRA buffers, would be evaluated during project-specific analysis.

COMMENT

S&W-3: Standards and Guidelines for stream surveys are not implemented before decisions on road building and harvest are made, especially for small headwater streams.

RESPONSE

See response to S&W-1.

Annual BMP monitoring results summarized in the annual Forest Plan Monitoring and Evaluation reports include additional detail on the implementation of forest plan standards and guidelines for stream protections. These are available in the record.

COMMENT

S&W-4: The DEIS does not properly assess sedimentation effects of log landings.

RESPONSE

Landings in the Tongass system are generally part of the road systems, which was assessed to their effect to water quality sediment as well as fish in both water and the fish sections. Text was modified to include reference to landings when discussing effects of roads.

Fish (FISH)

COMMENT

FISH-1: Logging, particularly old-growth, adversely affects salmon species. Additionally, the TTRA buffer does not prevent harvest in Riparian Management Areas (RMAs) of class III and IV streams, including patch cuts in Alternative 5, which may affect sediment, flow and nutrient in downstream fish bearing streams.

RESPONSE

Alternatives 1, 3 and 4 would generally prevent harvest in RMAs, including Class III streams. Alternatives 2 and 5 require that treatments in RMA must achieve stream process group objectives (Appendix D). In these alternatives, some harvest in the form of thinning in young-growth RMA is proposed outside of TTRA buffers along Class I, II and III streams. A watershed analysis, as described in Forest Plan Appendix C, would be needed for implementing any alternative that proposed to enter the RMA. BMPs for all alternatives combined with the Fish and Riparian Standards and Guidelines also apply. In addition, under Alternative 5, a 100-foot no harvest buffer has been applied around anadromous lakes

COMMENT

FISH-2: Logging results in elevated stream temperatures that are detrimental to fish and conditions may worsen in the project area considering future climatic change caused stream temperature increases.

RESPONSE

The Forest Service believes that the current and Final Proposed Forest Plan Standards and Guidelines (refer to Chapter 4, Chapter 5, and Appendix D) minimize riparian harvest in order to maintain stream-side shade. Chapter 3 Water and Fish sections disclose and discuss likely effects of past and planned riparian harvest on stream temperatures. The Forest Service does not see a need for additional restrictions at the Forest Plan level. Analysis conducted under the NEPA process would evaluate site-specific resource impacts and cumulative effects from individual timber sales or other extractive activities, and adjustments would be made as needed to ensure protection of these resources.

Additional information regarding temperature effects on small streams has been added. See Chapter 3 Water.

COMMENT

FISH-3: Logging increases stream flow, which is detrimental to fish.

RESPONSE

Stream flow effects will be extremely difficult to ultimately resolve given a number of limitations including disentangling the effects of multiple vegetation and road management treatments (including young-growth harvest) that overlap in both time and space, along with potential effects attributable to climate change (Grant et al. 2008). The EIS acknowledges uncertainty with respect to the effects of timber harvest and roads on stream flows.

COMMENT

FISH-4: Logging increases sediment input in streams including from increased landslides and may be a greater issue for Alternative 5, which would allow harvest to the banks of some class III and all class IV streams.

RESPONSE

The preferred alternative would allow harvest to the banks of Class III streams in existing young-growth stands for the first 15 years following signing of the ROD. All alternatives allow harvest to the banks of

Class IV streams. For steep slopes (>72%) and Class IV streams a slope stability analysis is required (page 4-61 and 5-11) and this requirement will minimize the number of management induced landslides and sediment to stream courses.

The standards, guidelines and management approaches in Chapter 5 describe how project level interdisciplinary teams are to consult Appendix D for objectives for riparian areas (including lakes and Ponds and Class III streams) and to protect those resources while providing a commercial young-growth product. All BMPs designed to keep sediment out streams and lakes still apply. Annual BMP monitoring conducted in 2014 concluded that prescribed BMPs were mostly or fully implemented during timber harvest, road, and facilities activities and have been effective in limiting or preventing sediment transport to streams (USDA Forest Service 2015)[1]. Timber harvest within riparian areas will still need to move the stand toward old-growth conditions to meet the objectives of the RMA.

The data presented in Table 3.3.5 in the DEIS was based on an assumption that a similar rate of landslide occurrence would occur as a result of young-growth harvest as occurred as a result of old-growth harvests. The estimate is based on the best available science at this time and the DEIS (pages 3-43 and 44) discusses the factors that contribute to the uncertainty. The draft forest plan still requires a slope stability analysis for timber harvest on slopes over 72%, although the on-site analysis of slope stability is not required for young-growth stands. The DEIS page 3-43 and 44 explains why this is a reasonable approach and why harvest on slopes over 72 percent will likely become less of an issue (page 3-43). The Forest Service has no data regarding landslide frequencies as a result of young-growth harvest in southeast Alaska. Text in the Chapter 3 Water was modified for clarification.

COMMENT

FISH-5: Logging in riparian areas including outside of the TTRA 100-foot buffers reduces large woody debris to streams, affecting fish habitat.

RESPONSE

Most of the large woody debris recruited to stream channels would occur from the TTRA buffer. However, some reduction in woody debris in stream channels could occur in RMAs outside of the TTRA buffer depending on alterative. Riparian Management objectives would be maintained as proposed under Alternatives 1, 3, and 4. Alternatives 2 and 5 require that management in young growth riparian areas accelerate old-growth characteristics to improve riparian function, but would allow some harvest in young-growth outside of TTRA buffers (refer to Water section). Alternative 2 allows only for commercial thinning of up to 33 percent of stand basal area over more than 36,000 RMA acres. This Alternative would likely have additional adverse effects to fish habitat not common to the other alternatives and could result in a loss of large woody debris to portions of floodplain and alluvial fan channel types. While Alternative 5 allows up to 10 acre openings and commercial thinning totaling no more than 35 percent of the total stand acres, it is estimated to be about 900 acres of total harvested RMA area and will only occur in the first 15 years of the finalization of the Plan Amendment. With these restrictions, the overall areas affected would be small relative to the total RMA acres in the Tongass. A watershed analysis (as described in Forest Plan Appendix C) would be needed for implementing any alternative that proposed to enter the RMA.

COMMENT

FISH-6: Logging adversely affects food for salmon by allowing harvest along class III and IV streams.

RESPONSE

It is understood that much of the food supply in fish streams originates from Class III streams and a significant portion of that food source is terrestrial, entering from riparian vegetation. Alternatives 1, 3 and 4 would generally prevent harvest in RMAs, including Class III streams. Alternatives 2 and 5 require that treatments in RMA must achieve stream process group objectives (Appendix D). In these alternatives,

[1] USDA Forest Service. 2015. Annual Monitoring and Evaluation Report for Fiscal Year 2014. R10-MB-770. Ketchikan, Alaska. Available online at: http://www.fs.usda.gov/detail/tongass/landmanagement/planning/?cid=stelprd3856205

some harvest in the form of thinning in young-growth RMA is proposed outside of TTRA buffers along Class I, II and III streams. A watershed analysis, as described in Forest Plan Appendix C, would be needed for implementing any alternative that proposed to enter the RMA. BMPs for all alternatives combined with the Fish and Riparian Standards and Guidelines also apply. As is noted in the Fish Section of the EIS, while changes to riparian vegetation on fishless streams will alter the composition of the food sources transported downstream, the overall effect on downstream fish streams over the long term is not clear, as actions near these small streams may have additional effects on stream production (Wipfi and Gregovich 2002).

COMMENT

FISH-7: Forest Service must retain or improve existing protections in both riparian and shoreline areas to protect salmon.

RESPONSE

The proposed plan components and BMPs would adequately protect fish and water resources on the Tongass National Forest and additional restrictions at the Forest Plan level are not necessary. Analysis conducted under the NEPA process would evaluate site-specific resource impacts and cumulative effects from individual timber sales or other extractive activities, and adjustments would be made as needed to ensure protection of these resources. The amount and location of land available for timber harvest varies by Alternative. Plan components protect watershed resources and watershed analysis will be conducted where conditions indicate the need.

COMMENT

FISH-8: Road construction in riparian areas increases stream temperature.

RESPONSE

The EIS Water and Fish sections discussion acknowledges and addresses the effects of roads and harvest on water quality, stream flow, and watershed condition. The EIS acknowledges that risks to aquatic resources would increase with more harvest and associated road construction and would vary by alternative (refer to the Fish and Water sections including additional text to the water section addressing potential temperature effects of roads). Site-specific evaluations, and if needed based on standard and guidelines, watershed analysis would be conducted for all timber harvest proposals to evaluate if specific adverse effects would occur and identify how best to modify the actions to minimize these specific effects.

COMMENT

FISH-9: Roads increase stream flow and peak flow timing, impacting stream channels and degrading fish habitat. The Forest Service should adopt a plan that involves fewer newly constructed road miles.

RESPONSE

The DEIS discusses and analyzes the effects of harvest and roads on streamflow on pages 3-64 through 3-68. The cumulative effects of roads and timber harvest on streamflow are discussed on pages 3-77 through 3-80.

COMMENT

FISH-10: Roads increase sediment entering streams and adequate stream buffers would reduce this sediment input.

RESPONSE

The EIS acknowledges the risks of roads to streams and the need to control sediment delivery to water bodies. Standards and guidelines for road construction have been developed to keep these risks at low levels with measures such as avoiding steep, unstable slopes, taking roads out of use after harvest is complete, including removal or stormproofing culverts. Recent monitoring demonstrates that the

maintenance program practices are effective in minimizing sediment transport from roads (USDA Forest Service 2015). Potential sediment effects are evaluated on a site-specific basis during the NEPA evaluation of timber sales and other projects, and as needed adjustments will be made to reduce the risks and ultimately the effects of roads to streams and control sediment delivery to water bodies.

COMMENT

FISH-11: Habitat access and fish passage at road crossings of streams must be considered and adequately monitored.

RESPONSE

Providing for fish passage at stream and road intersections to ensure fish migration is an important consideration when constructing, reconstructing, or storing forest roads. Standards and Guidelines direct specialists to avoid location of roads near fish-bearing streams and to seek locations that avoid fish streams, crossing streams when other locations are not feasible and fish habitat can be protected. All fish stream crossing installations in all action alternatives will be designed to meet fish passage standards. The Tongass National Forest strives to incorporate an adaptive management process to achieve the desired management goals and objectives for the fish passage at road crossings program. The adaptive management approach includes a continuous process of using, or developing, state-of-the-art assessment and restoration techniques followed by monitoring and adjustment of the techniques accordingly.

The Forest Service plans to continue to monitor all new and recent culvert installations in fish streams. A subsample of culverts installed from 1998 to present in fish streams are monitored annually. Only non-bottomless culvert installations are evaluated since they are more problematic for fish passage than bridges and bottomless culverts which routinely do not impede fish passage.

Furthermore, the transition to young growth will be managed at a pace that allows operators to adjust, adapt, and develop markets for new products. The duration and scale at which old growth harvest will be needed is unclear. Factors such as the role of State and private land in contributing wood supply to a viable industry; the availability of suitable young growth that is mature and economic to harvest; export and domestic processing policies; and fluctuations in domestic and world markets for forest products must be considered but are unpredictable, and will influence the timeframe for transition.

COMMENT

FISH 12: The Forest Service must consider options that would lessen road-building and protect salmon from its serious, varied harms.

RESPONSE

In the DEIS- Transportation, affected environment page 3-273 there is a description of the intent of the road construction to provide access to NFS lands. As mentioned in the environmental consequence section, page 3-275 the Forest will implement the Best Management Practices to protect water quality. The potential effects to the resources such as plants and fish are discussed in the subject resource sections. Relative to concerns associated with invasive plants, in the Plants, Environment & Effects section on page 3- 156 there is a discussion about the potential effects from road construction. This section mentions that the potential effect on risk of increased invasive plants as inferred from the amount of anticipated soil disturbance associated with alternative 5 would be intermediate relative to the other alternatives. There is a discussion in the cumulative effects section relative to invasive plants on pages 3-159- 3-160. In the end of this section the intent of the application of mitigation through the standards and guidelines as well as ongoing invasive control measures will contribute to minimize the cumulative effects of road building. The environmental effects relative to water are addressed in the section starting on page 3-49 and specific description relative to roads and road construction starts on 3-65. This section examines the miles of projected road construction relative to road densities as well as projected construction and reconstruction in beach/ estuary areas and riparian management areas. In the summary of this section on page 3-77, the analysis concluded that alternative 5 would have little overall effect to water quality in comparison to the current condition. The discussion of the cumulative effects of water

associated with roads starts on page 3-77. In this section, the Forest states that the application of the Best Management Practices will moderate the effect of the proposed action. In reference to details about the cumulative increase of estimated road miles is included on page 3-79. The environmental effects to fish are addressed starting on page 3-97 and a description of the fish and aquatic resources as well as streams and watersheds follows. Mention of roads and associated impacts is included on page 3-104, culvert replacements and removals at road crossings on page 3-109. Specific discussion of fish passage across roads is included on page 3-114- 3-115 and details associated with the number of stream crossings by alternative is displayed. Detailed description of alternative 5 and the potential impact on riparian management areas is included on page 3-123.

COMMENT

FISH 13: Inappropriately designed or located hydroelectric projects harm salmon.

RESPONSE

The analysis presented in this EIS is programmatic and provides overall Forest-wide direction. Project specific analyses are conducted for specific projects, such as hydropower developments. Project-level analyses quantify all the impacts—beneficial and adverse—of a proposed project. Potential impacts may include impacts to fish. Analysis conducted under the NEPA process would evaluate site specific resource effects and cumulative impacts from hydropower developments, and adjustments would be made as needed to ensure protection of resources.

Additional information has been added to the Fish section of the FEIS under the Renewable Energy Development subsection.

Chapter 5 of the Forest Plan includes the following renewable energy standard for fish:

“Assure that renewable energy projects continue the productivity of existing fish populations and habitat.”

COMMENT

FISH 14: The Forest Service should consult with the National Marine Fisheries Service on Essential Fish Habitat.

RESPONSE

The reasons for not consulting with NMFS regarding EFH is provided on page 3-125 in the DEIS. The EFH assessment and NFMS consultation will occur at the project scale for projects that affect essential fish habitat.

COMMENT

FISH-15: Climate change poses a serious threat to salmon that could be exacerbated by proposed actions in the Draft Forest Plan.

RESPONSE

The Forest Service has modified the Fish section discussion on climate change. We believe the current discussion of effects of climate change on fish resources and their habitat is adequately addressed in this section as revised.

COMMENT

FISH 16: Forest Service should measure the economic contributions of salmon produced on the Tongass.

RESPONSE

This request is beyond the scope of this Forest Plan Amendment.

COMMENT

FISH-17: One commenter noted that the DEIS overstates log transfer and log storage facilities effects on marine habitat, while another indicated that LTF facilities assessment was incomplete inaccurate and did not consider the current and future effects of these facilities on the marine fish and habitat conditions. It was also noted that the considered actions should be addressed in an Essential Fish Habitat (EFH) assessment.

RESPONSE

Explanation of need and potential number of LTFs is included in the Transportation Section of the FEIS. The effects of LTFs on marine fish, shellfish and habitat conditions was modified, expanded and presented in the Fish Section of the FEIS. The analysis includes further descriptions of mitigation and monitoring actions, state law requirements, and Forest Service limitations in place to protect marine resources from LTF and log storage sites and notes that future development of a substantial number of new LTF facilities is unlikely considering projected future harvest. The reasons for not developing and EFH analysis at this planning level is presented in the Fish section.

COMMENT

FISH-18: The Forest Plan should address road long-term road maintenance obligations under the CWA exemption for construction and maintenance of forest roads. It is not enough to only consider the initial construction of a road, and treat BMP violations that emerge later as merely part of an existing condition that are unrelated to any project decision.

RESPONSE

The DEIS/FEIS adequately discloses the effects of roads on fish passage and BMP compliance. The Forest Service plans to continue to address past culvert problems as funding is available. Determining funding levels is outside the scope of this Forest Plan Amendment EIS. Current standards and guidelines and Forest Service Handbook direction for culvert installation have requirements to ensure fish passage is provided when fish are present at the crossing areas. All road construction and reconditioning will be completed in conformance with Forest Plan Standards and Guidelines and best management practices (BMPs). Recent monitoring demonstrates that the current maintenance program practices are effective in minimizing sediment transport from roads (USDA Forest Service 2015)

As is stated in the DEIS (and FEIS) the Forest Service considers fish passage to be an important priority and has an ongoing program to eliminate or replace culverts that do not provide passage. Information on the status of the current culvert inventory relative to fish passage can be found in the Fish section of the Draft and Final EIS. The number of potential stream crossings identified in the EIS provides a relative approximation of the potential number of culverts by alternative (Table 3.6-4 on DEIS page 114-115); an exact number of future culverts cannot be determined prior to site-specific analyses. The exact number of culverts would be determined at a project level and the potential effects would be addressed as part of the project-specific NEPA analysis at that time. The Forest has a substantial database that identifies the status of nearly all existing fish stream – road crossings and includes detailed fish passage information (available in the project record).

COMMENT

FISH-19: The analysis of the effects from road crossings, both new and reconstructed, on fish passage and associated stream sediment is deficient in the DEIS.

RESPONSE

Additional information and clarification has been added to the Fish section of the Final EIS discussing risks to streams and fish habitat from road reconstruction including stream crossings. The Forest Service agrees that providing for fish passage at stream and road intersections to ensure fish migration is an important consideration when constructing, reconstructing, or storing forest roads. Current standards and guidelines direct specialists to avoid location of roads near fish-bearing streams and to seek locations that

avoid fish streams, crossing streams when other locations are not feasible and fish habitat can be protected. All fish stream crossing installations in all action alternatives will be designed to meet fish passage standards (refer to references cited in https://www.researchgate.net/publication/265814797_Road_Surface_Erosion_Part_1_Summary_of_Effects_Processes_and_Assessment_Procedures for further information).

COMMENT

FISH-20: The DEIS fails to recognize that damage to fish habitat means loss of fish production and harm to the fishing industry.

RESPONSE

See response to FISH-1. Effects to fish populations from future actions cannot be directly quantified given the number of outside variables, such as ocean conditions and population fluctuations. However, past, present and future actions are discussed by quantifying factors known to have increased risk to fish habitat. All of the proposed alternatives have a substantial number of measures that would be implemented during timber harvest to protect fish habitat, many of which were not in place during most of the past timber harvest.

COMMENT

FISH-21: The DEIS does not clearly present effects to fish populations and watershed conditions.

RESPONSE

The DEIS/FEIS adequately discloses and discusses the effect of each alternative, including relative to road-related parameters, in the Water and Fish sections of Chapter 3. These and other site-specific variables would be evaluated more precisely during project-level planning.

COMMENT

FISH-22: Fishing, largely commercial, has devastated populations of the wild salmon and steelhead in our rivers throughout Southeast Alaska.

RESPONSE

The FEIS provides baseline information on commercial fish harvest, including past harvest in Chapter 3 Fish. In Chapter 3 Wildlife, the FEIS acknowledges that the amount of human activity in the marine environment associated with Forest management activities is only a fraction of the total amount of human activity occurring in the marine environment. Some of the other activities include commercial fishing, sport fishing, hunting, subsistence, tourism, and mariculture. Assessing the overall effects of past commercial fishing on wild populations throughout Southeast Alaska is outside of the scope of this amendment.

Riparian (RIP)

COMMENT

RIP-1: No-cut buffers should apply to all anadromous water bodies, including lakes, ponds, and wetlands.

RESPONSE

All alternatives provide old growth no-harvest buffers along Class I, II, and III streams. TTRA directs that no commercial timber harvest is allowed within a minimum of 100 feet horizontal distance either side of Class I streams and Class II streams that flow directly into a Class I stream. RMAs outside of TTRA are protected in accordance with the intent of the Anadromous Fish Habitat Assessment (1995), through application of the direction contained in Riparian Management Area Standards and Guidelines (Appendix D) and through application of BMPs. Riparian buffers vary in width, depending on site-specific conditions, including stream class, channel type, and the risk of windthrow. The areas identified in the comment are generally included in the riparian buffers.

In reference to young-growth outside of TTRA buffers, Alternatives 1, 3 and 4 would generally prevent harvest in RMAs. Alternatives 2 and 5 allow only for commercial thinning in RMA's with maximum removal varying from 33 percent (Alternative 2) to 35 percent with created openings (< 10 acres) allowable. Commercial thinning in Alternative 2 would occur over a majority of all the available young-growth RMA areas. Alternative 5 commercial thinning is limited in area based on model assessment. Forest Plan Standard S-YG-RIP-02 constrains young-growth harvest in these areas to a one-time only entry and to the first 15 years unless best available scientific information shows that additional entries are: a) warranted, and b) meet the LUD objectives. However, the harvest prescription is less restrictive. Under all alternatives, any commercial harvest in RMAs (excluding TTRA buffers) must be compatible with direction contained in Riparian Management Area Standards and Guidelines (Appendix D). A watershed analysis would be required for implementing any alternative that proposed to enter RMA. BMPs combined with the Fish and Riparian Standards and Guidelines would also apply. Every project and activity must be consistent with the applicable plan components, including the desired conditions. (36 CFR 219.15(d))

In addition, under Alternative 5, a 100-foot no harvest buffer has been applied around anadromous lakes.

COMMENT

RIP-2: The language of TTRA mandates buffers of "at least" 100 feet and the effect of an RMA would seem to be widening that buffer.

RESPONSE

Forest Plan Appendix D provides a detailed description of the standards and guidelines applicable in Riparian Management Areas, including the requirements of TTRA.

COMMENT

RIP-3: The proposed action is concentrating timber production in the most valuable areas. Targeting riparian areas for timber harvest will use and develop legacy roads and landings that should be allowed to continue their natural path to restoration, especially in floodplains and on alluvial fans. Harvesting in riparian areas will affect LWD recruitment, sediment delivery, and hydrologic connectivity.

RESPONSE

See response to FISH-5 and FISH-10. The DEIS/FEIS discloses these effects, which must also be considered at the project level. Under all alternatives, any commercial harvest in RMAs must be compatible with direction contained in Riparian Management Area Standards and Guidelines (Forest Plan Appendix D). A watershed analysis (Forest Plan Appendix C) would be required for implementing any

alternative that proposed to enter RMA. BMPs combined with the Fish and Riparian Standards and Guidelines would also apply.

The DEIS acknowledges that existing legacy roads would be reconstructed. However, it is unlikely that many of the original valley bottom (floodplain and alluvial fan) legacy roads would be used to access timber because of the risk to productive fish habitat and cost of reconstruction. This would be evaluated at the project-scale.

Botanical Resources (BOT)

COMMENT

BOT-1: Sensitive Plants: The USFS should provide more detail in the Forest Plan Amendment regarding the largest population of one sensitive plant, lesser round-leaved orchid, and the recent monitoring results indicating a decline in known sightings within the Big Thorne Project area on Prince of Wales Island. The USFS should also address climate change as a threat to the species. The FEIS should more specifically address these concerns and the body of literature related to this sensitive plant.

RESPONSE

Forest Service policy requires that a review of programs and activities be conducted to determine their potential effect on threatened and endangered species, species proposed for listing, and Regional Forester-designated sensitive species (FSM 2670.31-2670.32). The Forest Service has prepared a Biological Evaluation (see FSM 2670.3) for Plants for the Forest Plan Amendment (see Forest Plan Amendment Planning Record) that presents the analysis and determination of effects for the Forest Service sensitive species, including the lesser-round leaved orchid. Preparation of a Biological Evaluation (BE) as part of the National Environmental Policy Act (NEPA) process ensures that sensitive species receive full consideration in the decision-making process.

Sensitive plants are those plants identified by the Regional Forester for which population viability is a concern on National Forest System (NFS) lands within the region. A viability concern is identified by either a significant existing or predicted downward trend in population numbers or density, or a significant existing or predicted downward trend in habitat capability that would reduce a species' existing range in the planning area. For forest planning purposes, a planning area is one or more identified National Forest(s) (FSM 2605).

The analysis area for the Plan Amendment Plant BE is the Tongass National Forest (i.e., the plan area), which includes all biological populations existing in whole or in part of the plan area. Because population viability is evaluated at a Forest-level, we considered all known occurrences of the lesser round-leaved orchid throughout the plan area, which includes a larger land base than the analysis conducted for the Big Thorne Timber Sale (i.e., Big Thorne project area).

Recent population mapping of all occurrences of the lesser round-leaved orchid by the Alaska Natural Heritage Program conducted in 2015 using national mapping standards and definitions of populations[2] resulted in 61 distinct populations. Of the total area occupied by the 61 known populations, 44 percent is located within non-development LUDs and 56 percent is located within development LUDs (USDA Forest Service 2015).

We acknowledge that approximately 50 percent of the known occurrences of lesser round-leaved orchids occur on Prince of Wales Island. Therefore, half of the known occurrences exist elsewhere on the Tongass. The largest occurrences are concentrated in east-central Prince of Wales Island near Thorne Bay, AK. Other concentrations are on western Revillagigedo Island, Gravina Island, and southern Etolin Island. The northern limit of known occurrences on the Tongass is on Wrangell Island. (USDA Forest Service 2015).

A recent pilot monitoring of population trend for this species on Prince of Wales Island suggests a potential decrease in population density of 57 percent in a two-year monitoring period (USDA Forest Servie 2015). The severity of the potential downward trend emphasizes the need for continued monitoring of lesser round-leaved orchid to understand whether the short-term pattern observed suggests a possible concern about the long-term persistence of this species on this portion of the Tongass. Factors related to a potential downward trend are uncertain and may include a this species' inherent dormancy (and therefore cryptic nature); mycorrhizal associations of the plant and soil; herbivory; changes in soil

[2] Populations are defined differently than occurrences. Rare and sensitive plant occurrences documented in the Tongass National Forest database do not always correspond to the definition of a population.

moisture regime over the long term as a result of long-term climatic variation; management impacts, such as changes in light and soil regimes as a result of timber harvest and road construction, among other factors. Furthermore, the monitoring sample size was small, resulting in high variation among the sample plots. A larger number of sample plots would be needed to reduce this variation. Thus, we have a limited ability to make robust conclusions regarding trends indicated by the monitoring results. Because monitoring is focused on a small sample of known locations, which are limited to only a portion of the Forest over a two-year monitoring period, inferences regarding downward trends may only apply to populations on the portion of Prince of Wales Island where monitoring has occurred. Current monitoring, does not sample populations across the full range of this species in the plan area and; therefore, should not be used to make accurate inferences as to this species' viability status across the Tongass.

Substantial timber harvest and road construction has occurred within development LUDs within the range of this species on the Tongass. The Old-growth Conservation Strategy provides for large reserves of old-growth habitat, in particular within the non-development LUDs; resulting in conserving at least 40 percent of the known populations of lesser-round leaved orchid and their habitat across the Forest.

Key threats to this species and its habitat in the development LUDs continue to be impacts from timber harvest and road construction. These threats were analyzed in Chapter 3 of the DEIS (pages 3-142 through 3-159) and in the Draft Plant BE (see Forest Plan Amendment Planning Record). Several large-scale harvests of mostly mature to old-growth timber are currently being planned within the range of this species. If implemented, these projects could impact a substantial amount of habitat and known occurrences. However, Forest-wide standards and guidelines in the approved Forest Plan (USDA 2008b, page 4-41) have been implemented in current and on-going project NEPA analysis and have provided protection of many lesser round-leaved orchids occurrences by buffering and avoiding known occurrences during timber layout for several timber sale areas; illustrating a concerted effort to avoid and minimize impacts to known occurrences from timber harvest and road construction. Continued implementation of the standards and guidelines are fully anticipated for the life of the Plan Amendment and therefore, impacts will be minimized.

Predicted increase in average temperatures in southeast Alaska due to climate change could theoretically expand the range of the lesser round-leaved orchid and other sensitive plants northward on the Tongass. Recent collaboration with the Alaska Natural Heritage Program will provide the Tongass with better information on future climate change scenarios associated with several sensitive plants (work in progress). Until we receive this work on species assessments and the associated climate change scenarios, the future expansions or contractions in sensitive plant ranges within the Planning Area is uncertain. Unlike the research and findings related to the effects of yellow-cedar due to climate change (Hennon et. al. 2016), no specific work has been done on any of the sensitive plants in Region 10 related to climate change impacts on their distribution and extent.

Fragmentation of habitat due to past and potential future management activities could inhibit the ability of lesser round-leaved orchid and its habitat to adapt or migrate. As the level of old-growth harvest decreases under this Forest Plan's transition period, fragmentation will become less of a concern. The lesser round-leaved orchid is also subject to browsing or grazing by a number of herbivores, but the effects of herbivory on the Tongass populations is currently not known. Collection or trampling by recreationists is likely to be a minor threat, since the flowers are small and the plant can be difficult to see in its shady forest habitat. Additionally, the rarity of this species across its range may be at least partially due to the rarity of its pollinators.

We recently evaluated the lesser-round leaved orchid in light of the Tongass old-growth Conservation Strategy and our most recent information on the numbers of occurrences within the plan area (USDA-FS 2015). We concluded that with 44 percent of their population areas occurring within non-development LUDs, combined with the on-going and active implementation of 2008 Forest Plan direction in this Forest Plan for avoiding and minimizing impacts to this species, that current science evidence does not indicate a substantial concern for the capability of lesser round-leaved orchid to persist over the long-term in the Tongass plan area (USDA Forest Service 2015).

Furthermore, in our evaluation of the direct, indirect, and cumulative effects as required through the BE process, we considered timber harvest and road construction – the two management actions identified in

this Plan Amendment NEPA analysis as most impacting - and conclude that the consequence of adverse effects on currently unknown and known occurrences in the Tongass would be low because approximately 40 percent of the known occurrences are not currently threatened by proposed management activities. In addition, Forest-wide standards and guidelines under all alternatives would consider protection to minimize impacts to known occurrences of this species and new occurrences of this species located during project surveys. Because, at the most, approximately 17 known occurrences are expected to be within old-growth harvest units, and another 29 known occurrences are expected to be within young-growth harvest units, out of the 291 distinct occurrences on the Tongass, there would be a relatively low level of risk to this species' viability. Because of this plant's abundance outside the Tongass no alternative would result in a trend toward federal listing (see the Biological Evaluation for Plants in the planning record, USDA 2016)

COMMENT

BOT-2: The DEIS needs to provide more detail about Forest Service plans to treat invasive plants – particularly the use of herbicides.

RESPONSE

Currently the Forest uses over 30 specific mitigation measures for invasive plant prevention and control for all management actions, ranging from timber sale programs, transportation planning and maintenance programs, renewable energy development, recreation and wilderness management and other special uses. Mitigation measures are identified in a draft guidance document that is currently undergoing revision (Krosse, P. March 2014). This document follows specific guidance for prevention and control measures as described in FSM 2900 (Invasive Species Management – November 2011). Additional directives associated with integrated pest management include FSM 2070 (Native Plant Material Policy) and FSM 2150 (Pesticide Use Management and Coordination Policy), the latter of which is particular to the use of herbicides. The draft guidance document provides 38 specific best management practices (BMPs) associated with invasive plants along with several exhibits which provide more information and direction on process and methods for applying these mitigation measures.

Due to the draft status of this document, it is premature to include it in the FEIS. However, the full intent of implementing mitigation measures associated with invasive plant management is comprehensively delineated in FSM 2900, which is incorporated by reference in the FEIS.

Wildlife (WILD)

COMMENT

WILD-1: The Forest Service has not provided its assessment of wildlife viability or disclosed its reasoning and conclusions in the DEIS as it relates to well-distributed, viable populations.

RESPONSE

See response to PLR-2.

A thorough viability analysis was conducted during the 1997 Forest Plan revision. The Tongass Conservation Strategy was designed to provide enough old-growth habitat strategically placed across the Tongass National Forest to provide for viable and well distributed populations under old-growth logging for 100 years; old-growth associated species were emphasized because that habitat is what was targeted for harvest at the time. The basic Conservation Strategy of old-growth habitat reserves is still in place under this proposed amendment; no old-growth harvest is proposed in areas important to the Conservation Strategy such as old growth reserves, beach and estuary buffers, and riparian management areas.

Young-growth harvest in conservation areas (Old-Growth Habitat LUD, RMA, beach) is limited by plan components established in Chapter 5 and include: maximum opening size, maximum percent of each stand that could be harvested, a one-time entry per stand, and desired conditions to accelerate old-growth characteristics. If young growth harvest is proposed within Old-Growth Habitat LUD, an interagency biologist team will review the possibility of modifying the boundaries to exclude that young-growth in exchange for increasing the old-growth protected within the reserve boundary.

One purpose and need of this amendment is to transition to primarily young-growth harvest in about 15 years. Although old-growth harvest will still occur under the amended Forest Plan, it will be at levels lower than those analyzed under the 1997 Forest Plan and will be for a shorter duration (10-15 years) than previously evaluated (100 years). There will be a phased approach to the transition - the maximum old-growth harvest (for 10 years or so) and maximum young-growth harvest (beyond 15 years) will not be taking place at the same time. . In addition, the level of old growth harvest that occurred since 1997 has been less than the maximum anticipated in the mid-1990s viability analysis.

Standards and Guidelines in Chapter 4 also remain in place, such as designing projects to maintain landscape connectivity; nest buffers for goshawks, marbled murrelets, and herons and raptors; and den buffers for wolves.

COMMENT

WILD-2: The Forest Service should make a concerted effort to maintain remaining wildlife corridors and leave strips in heavily fragmented developed areas.

RESPONSE

One Forest-wide Goal stated in Chapter 2 of the Forest Plan is “Maintain the abundance and distribution of habitats, especially old-growth forests, to sustain viable populations in the planning area” and this is considered during project planning. In addition, Forest-wide Standard and Guideline WILD1.VI pertains to Landscape Connectivity: projects are to be designed to maintain landscape connectivity between large and medium Old-Growth Habitat reserves and other forested non-development LUDs, and young-growth treatments that accelerate old-growth characteristics should be considered in beach fringe, riparian buffers, and other lands not suitable for timber production.

In order to transition in 10-15 years as outlined in the Secretary’s Memo and brought forward in the Purpose and Need, all young-growth lands were considered. Since the age of the young-growth stands is a limiting factor, the oldest stands of young growth are being considered for harvest to facilitate the transition. Many of the older young growth stands were harvested prior to having the current standards and guidelines and other restrictions in place; these older young growth stands that will have restrictions

or limitations on harvest under the proposed Forest Plan that will contribute to protection of habitat. For example, some of the oldest young-growth stands may have unmapped streams that will require stream buffers. Some areas may occur on soils that would have harvest deferred on them under the current forest plan. These areas are expected to add structure and habitat in patches and/or corridors in many of the older young growth stands.

All alternatives provide old growth no-harvest buffers along Class I, II, and III streams. TTRA directs that no commercial timber harvest is allowed within a minimum of 100 feet horizontal distance either side of Class I streams and Class II streams that flow directly into a Class I stream.

See response to CONS-11.

COMMENT

WILD-3: Specific attention should be made to improve habitat conditions in ecologically important areas and emphasize timber production in intensive rotational forestry areas near mills and roads.

RESPONSE

"Include a young-growth management program to maintain, prolong, and/or improve understory forage production, and to improve habitat distribution, including future old-growth characteristics in young-growth timber stands for wildlife on lands both suitable and not suitable for timber production" is a Forest-wide Objective from Chapter 2 of the Forest Plan and is considered during project planning. At the Forest Plan level, land use designations are used to designate general areas where development such as timber harvest can occur. Site-specific information regarding economics (for example, logistics and proximity to infrastructure) and resource considerations (for example, ecological importance) are evaluated by an interdisciplinary team during project planning. Specific stand treatment objectives are also completed at the project level.

The Tongass uses intermediate silvicultural treatments to meet a variety of objectives in our young-growth stands. Precommercial thinning is the most predominant management tool prescribed to improve tree growth and stand vigor, as well as allow for more light to reach the understory, allowing a more robust and persistent understory including forage. Follow up treatments can be planned for young growth where the objective is other than long-term rotational harvest. Some of these treatments may include creation of canopy gaps, pruning and/or slash reduction. In areas of timber intensive objectives, precommercial thinning can improve the understory and stand health for the benefit of wildlife and other resources during the decades the stand is growing prior to reaching economical or ecological maturity.

COMMENT

WILD-4: The LRMP suitability determinations failed to respond to multiple use values in heavily logged biogeographic provinces on the central and southern end of the Tongass where high volume and large tree POG already have substantial cumulative impacts.

RESPONSE

The DEIS acknowledged that parts of the Forest have been logged more intensively than others, including Prince of Wales Island. The DEIS, page 3-202, states: "As development continues through timber harvest and associated activities such as roadbuilding, and community expansion, particularly in areas where extensive development as already occurred (i.e., Prince of Wales Island), maintaining connectivity and roadless refugia will become increasingly important, particularly for wide-ranging species whose distribution depends on some level of connectivity across the landscape." In addition, Tables 3.9-16, 3.9-17, and 3.9-18 show cumulative impacts by biogeographic province for total POG, high-volume POG, and large-tree POG for all ownerships across Southeast Alaska, clearly showing some biogeographic provinces with higher percentage harvest than others.

In order to expedite transition away from harvesting old growth, all young-growth lands were considered. Since the age of the young-growth stands is a limiting factor for commercial harvest, the oldest stands of

young growth are being considered for harvest to facilitate the transition, and it is necessary to harvest older young-growth stands in these areas of the Forest in order to meet the stated Purpose and Need of the amendment. This harvest also provides an opportunity to improve habitat conditions for wildlife and fish and improve stand function in places that could benefit from restoration; the opportunity to advance these stands toward old-growth conditions would be lost if young growth was not considered in previously harvested areas.

Old growth timber harvest will be limited to the Timber Management, Modified Landscape, and Scenic Viewshed LUD as is allowed under the 1997 and 2008 Forest Plans. Changes to these LUDs as suitable for old growth harvest are not proposed as part of this amendment. Legacy standards and guidelines apply to old-growth harvest in heavily harvested VCUs. To complete the transition to primarily young growth harvest, it is inherently necessary to do that young growth harvest in areas with previous old growth harvest. Roadless area direction also limits timber harvest to areas that have roads, which generally means past timber harvest.

Also see WILD-6

COMMENT

WILD-5: All alternatives would result in federal lands remaining at the stem exclusion phase which is not consistent with the need to provide long-term understory forage production.

RESPONSE

The EIS acknowledges that the management of young-growth stands for commercial timber harvest will reset the stand development process when even-aged harvest is used, transitioning older young-growth stands currently in the stem exclusion stage back to stand initiation. Young growth stands that would be harvested under the proposed amendment are typically a minimum of 65-75 years old (DEIS page 3-310), and have not yet reached the understory reinitiation stage which occurs at around 150 years of age in Southeast Alaska (Alaback 1984); Alaback also found that forests with open, patchy canopies tend to produce the most understory vegetation while those even-aged forests in the 30 – 150 year produced the least understory vegetation.

Over time, active management of these stands for commercial timber harvest (repeated entries) would delay the development of old-growth. Alternative 5 addresses this by including a one-time entry for young-growth harvest in the beach fringe, RMAs, and Old-Growth Habitat LUD during the first 15 years after Plan approval (S-YG-BEACH-02, S-YG-RIP-02, and S-YG-WILD-02) and a desired condition to accelerate old-growth conditions in these areas (DC-YG-BEACH-01, DC-YG-RIP-01, and DC-YG-WILD-01). Ultimately, all of the action alternatives would result in the maintenance of more old-growth forest across the landscape than originally assumed during the development of the 1997 Tongass Conservation Strategy.

COMMENT

WILD-6: Cumulative effects of non-federal logging heightens the need to downscale federal second growth logging. This is especially apparent in areas such as Kosciusko Island, which was acknowledged by the Forest Service in other analysis, and likely in POW and southern Revilla due to the scale of foreseeable Sealaska and Alaska Mental Health Trust logging, other smaller scale areas.

RESPONSE

The Draft EIS presents the cumulative effects of old-growth timber harvest under each alternative in Section 3.9 – Biodiversity (Table 3.9-16). As noted in the comment, the EIS describes assumptions made about future harvest on non-NFS lands. However, the EIS analysis assumed that these harvested lands never return to old-growth condition (i.e., they are conservatively assumed to make no contribution over time to the old-growth land base once harvested). This assumption also is conservatively used for existing young-growth on non-NFS and NFS lands.

The cumulative effects discussion notes that the future cumulative reduction in POG would result in increased fragmentation and loss of connectivity. It further notes, that edge effects such as shifts in species composition may reduce natural biodiversity over time by favoring some species over others and that these effects would be lessened by the action alternatives which propose a transition to young-growth harvest. Based on the analysis included in Table 3.9-16, additional discussion has been added to the Final EIS identifying where on the Tongass, these effects are most likely to occur (i.e., those areas that have experienced the most past harvest). However, more detailed, location-specific analyses of cumulative effects, such as in the Kosciusko Vegetation Management and Watershed Improvement EA referenced by the commenter, necessarily occur at the project-level where proposed harvest units can be identified and effects can be evaluated in the context of the surrounding landscape (i.e., the presence and proximity of non-NFS lands, future land exchanges, and other factors in relation to proposed harvest units or other activities on NFS lands). Any future proposed project on the Tongass would undergo its own NEPA analysis and must demonstrate consistency with the Landscape Connectivity standard and guideline. Moreover, it is possible at the project level to adjust the location of proposed actions to minimize cumulative impacts. For these reasons, the cumulative effects analysis in this EIS adequately addresses timber harvest on non-NFS lands and therefore does not warrant republication of the Draft EIS.

Also see WILD-4.

COMMENT

WILD-7: The Forest Service needs to provide more information on how young-growth management will benefit wildlife and explain what is meant by "maintain" and "improve."

RESPONSE

The 2012 Planning Rule (36 CFR 219.19) defines maintain for ecological conditions: "To keep in existence or continuance of the desired ecological condition in terms of its desired composition, structure, and processes." It also says this may be done by active or passive management or both depending on the circumstances. Although "improve" is not defined in the Planning Rule, the general definition would simply mean to make better, which in this case would be to move the habitat toward the Forest Plan desired conditions, or toward the habitat conditions needed to support a particular species if that is the objective of a specific project. Habitat preferences are discussed in the FEIS for selected species (Wildlife section) and in general terms of old-growth (Biodiversity section). It should be noted that the wildlife components of the Forest Plan remain under the 1982 Planning Rule, and specific updates to meet 2012 Planning Rule requirements are not proposed under this Forest Plan Amendment.

The transition to young-growth harvest proposed in the action alternatives would have a beneficial effect to wildlife species associated with old-growth forest by reducing the amount of old-growth timber harvest that would occur over the planning horizon. As described in Appendix D, about 400,000 additional acres of old growth will occur on the Tongass after 100 years of implementation under one of the current transition alternatives compared with the amount of old growth projected to be existing in 100 years under the 1997 Forest Plan. When developed for the 1997 Forest Plan, the Conservation Strategy was based on this assumed harvest level. This factor alone provides a tremendous benefit for those wildlife species that use old-growth habitat. Similarly, the overall level of road construction would be reduced substantially from the level assumed under the 1997 Forest Plan. Over 2,000 fewer miles of road would be developed over 100 years, which is expected to have substantial benefits for species affected by road density (e.g., wolf, marten). Finally, direct benefits of young-growth management will result by moving stem exclusion stage stands back to the stand initiation stage; this will be especially beneficial in locations with very high densities of stem exclusion stage forest. The EIS also notes in a number of locations the potential benefits of precommercial and commercial thinning and other silvicultural treatments.

COMMENT

WILD-8: The DEIS inappropriately grouped golden-crowned kinglet with early seral species.

RESPONSE

The EIS affected environment of Section 3.10 – Wildlife correctly describes the golden-crowned kinglet as being associated with old-growth interior forest conditions. The effects analysis correctly identifies this species as one that primarily nests in POG forest, and therefore could be affected by old-growth timber harvest. The statement identifying this species as being associated with early seral habitat has been corrected.

COMMENT

WILD-9: The amount of old-growth logging proposed likely violates the Endangered Species Act.

RESPONSE

The Tongass does not have any threatened or endangered species under ESA that use old-growth forests.

WILD-10. The Forest Service should evaluate the cumulative effects of logging on all lands, including State managed lands, on wildlife and habitat connectivity.

RESPONSE

Cumulative effects to wildlife considered in Chapter 3 Wildlife, including evaluating deer habitat capability from all land ownerships. When combined with other management activities occurring on non-NFS lands, all alternatives would produce additional impacts associated with continued old-growth harvest to species for which this forest type is optimal habitat, such as goshawks, marten, mountain goats, red squirrel, red-breasted sapsucker, hairy woodpecker, brown creeper, and bat species. However, these declines in habitat (and associated effects such as fragmentation) would be lessened to some extent through the transition to young-growth harvest on NFS lands under Alternatives 2, 3, 4, and 5.

COMMENT

WILD-11: Commercial thinning is not beneficial to wildlife or their habitats. Second growth stands should be allowed to return to old growth stands in order to protect wildlife.

RESPONSE

Additional text has been added to the Final EIS to acknowledge that although research has shown that the removal of commercial-sized trees can promote tree growth and understory vegetation development, there remains some uncertainty about the effectiveness of young-growth treatments in benefiting wildlife

COMMENT

WILD-12: Logging in beach fringe, riparian areas, and old-growth reserves should be prohibited, or at least deferred for 15 years to protect sensitive avian species. Literature related to the effects of timber managed on avian species is limited in the EIS, and additional references should be added. Furthermore, the Marbled Murrelet (*Brachyramphus marmoratus*) should be considered in the forest planning.

RESPONSE

The potential adverse effects to wildlife associated with young-growth harvest in the beach and estuary fringe, RMAs, and the Old-growth Habitat LUD are discussed in the Wildlife section and more broadly, in the context of the Forest Plan conservation strategy, in Appendix D of the EIS. The EIS analysis includes alternatives which do not include harvest within the beach and estuary fringe, RMAs, and/or the Old-growth Habitat LUD.

The marbled murrelet was one of the species selected for detailed evaluation during the development 1997 Forest Plan conservation strategy. For the 1997 Forest Plan, a series of panel assessments were conducted for a select group of species, including the marbled murrelet (Smith 1996), to evaluate the likelihood that various plan alternatives would maintain an abundance and distribution of habitat sufficient

to support viable and well-distributed populations across the planning area over the planning horizon. The panel assessment process was designed to provide the context for, and guide the development of, the Forest Plan Conservation Strategy. The results of the panel assessments are included in Appendix N to the 1997 Forest Plan FEIS (USDA Forest Service 1997b) and summarized (and supplemented with new information) in Appendix D of the 2008 Forest Plan FEIS (USDA Forest Service 2008b). A more detailed discussion of the marbled murrelet has been added to the Final EIS including an additional discussion of viability, drawing from the findings of the 1997 panel assessments has been added to the Final EIS. Specific Forest Plan components for this species are not proposed under this focused Forest Plan Amendment.

COMMENT

WILD-13: The EIS underplays the importance that deadwood (both standing and on the ground) has to wildlife. Furthermore, the EIS should consider the effects that forest management would have on all endemic avian subspecies in Southeast Alaska that may be restricted to a limited area (e.g., Swainson's Thrush and Song Sparrow), as well as Marbled Murrelet. In addition to protecting the 100 acres surrounding goshawk nests, the EIS should adopt guidelines for conservation within the projected goshawk foraging territory.

RESPONSE

The ecological values of young-growth stands are discussed in the Wildlife Section of the EIS and in Appendix D. The marbled murrelet was one of the species selected for detailed evaluation during the development 1997 Forest Plan conservation strategy. Additional discussion of this species has been added to the Final EIS. As noted in the comment, many species rely on habitats within the beach and estuary fringe. Effects of young-growth harvest on a subset of wildlife species, representative of others with similar habitat characteristics, is included in the Wildlife section including a discussion of endemic species. At the project level, additional endemic species could be addressed in detail taking into account site-specific landscape characteristics and species of greatest conservation need. These would include additional endemic species limited to certain portions of the Alexander Archipelago. Regarding goshawks, no additional changes in goshawk standards and guidelines are proposed under this Forest Plan Amendment. The DEIS statement about monitoring is in reference to the Tongass Monitoring and Evaluation Program; although the program is concurrently undergoing review, no changes are proposed under this Forest Plan Amendment.

See response to WILD-12

COMMENT

WILD-14: The productivity of thinned forests can diminish after 20-30 years following thinning treatment. The longevity of treatments should be considered when modeling the benefits of these treatments on deer habitat, as multiple treatments over time may be necessary to maintain adequate wildlife habitat.

RESPONSE

The interagency deer model does not have the capability of taking into account different types of young-growth treatments. Therefore, it is conservative in that it does not account for the benefits of young-growth management over time, including methods such as pruning that might extend the longevity of young-growth treatments. However, these benefits are described qualitatively in the discussion in the Wildlife section under Deer. A statement has been added to the final EIS disclosing that the forage in clearcuts is of lower nutritional quality than that of old-growth forest.

Deer (DEER)

COMMENT

DEER-1: Forest Service should avoid projects that are likely to reduce deer populations in areas where deer density is already below Forest Service standards.

RESPONSE

An interdisciplinary team of resource specialists reviews possible effects of the project during project specific analysis, including changes in deer habitat. That analysis includes site-specific and landscape factors at an appropriate scale for each species. Each project implemented under the amended plan must document in the project decision how the project is consistent with the applicable plan components, including standards and guidelines.

No changes are proposed to Chapter 4 standards and guidelines for deer density. WILD1.XIV.A.2 is a guideline to ensure consideration and evaluation of deer habitat needs during project planning, not a bare minimum deer density requirement for all agency actions. Use of the words "where possible" and "generally considered" convey that this is not an absolute requirement: "Provide, where possible, sufficient deer habitat capability to first maintain sustainable wolf populations, and then to consider meeting estimated human harvest demand. This is generally considered to equate to the habitat capability to support 18 deer per square mile (using the habitat capability model outputs) in biogeographic provinces where deer are the primary prey of wolves." In addition, it goes on to say the biologist should consider additional local factors rather than relying solely on model outputs. Many places on the forest may not meet this number naturally and there are places where deer are not the primary prey item. This standard and guideline, while important, is only one part of a comprehensive strategy for maintaining population viability.

COMMENT

DEER-2: Deer model results were not presented by WAA, denying the public a clear view of the Plan's impact. Table 3.10-10 is mislabeled with a title saying that the data in the table is by WAA, when in fact it is by province.

RESPONSE

This information was summarized in the FEIS and is available by WAA in the project record. The title of Table 3.10-10 has been corrected.

COMMENT

DEER-3: The DEIS should present deer model results for all lands; not just for NFS lands only. This practice of limiting the analysis of such impacts to only federal lands conceals impacts because the indirect effect of the alternatives acts on the environment as a whole regardless of land ownership, even if the direct effect is just on the federal land. (NGO2-061)

RESPONSE

The Tongass National Forest is the largest land owner in Southeast Alaska. Non-National Forest (NFS) ownerships lands are not governed by the same management direction as the Tongass National Forest (Forest Plan standards and guidelines, for example). In addition, the Forest Service does not maintain habitat data for all of the non-NFS lands in Southeast Alaska to be able to enter accurate data into the model. For these reasons, a zero value is assigned to all non-National Forest ownerships to provide a worst-case analysis. In addition, non-NFS lands are not within the jurisdiction of the Forest Service to determine what activities will take place or when / where those activities will occur (if any). Therefore, results are presented for NFS land only. Although reasonably foreseeable activities on other lands can be generalized (DEIS page 3-260 and Appendix C) to include probable timber harvest, road building, residential development, mining, recreation and tourism, specific size and timing of such activities over the planned 100 year harvest rotation are not known. As an example, although an Alaska Mental Health

Trust land exchange is proposed, various alternatives are being considered and a selected alternative is years away; therefore a site specific analysis under a separate NEPA is considered to evaluate effects of all alternatives of that proposal.

Table 3.10-15 in the FEIS shows deer density across all ownerships. The habitat capability outputs are still based on NFS land only but the density calculation is now shown for both NFS and all lands.

COMMENT

DEER-4: The DEIS violates NEPA by presenting deer model results as percent change, which is poor quality, misleading information because it conceals both the state of the environment and the impacts upon it. Deer model results should show an alternative with an immediate end to old-growth logging and a 250 year output.

RESPONSE

The deer model is used as a relative comparison tool between alternatives and at the Forest scale represents a general trend across the planning area. Percent change is used since these are modeled results, not actual deer known to inhabit the forest. Differences among deer habitat capability (theoretical deer numbers) do occur in the alternatives but the differences are small, as displayed in Table 3.10-10 in the DEIS.

The Forest Plan amendment is proposing changes primarily to young growth harvest; stands that would be proposed for harvest are assumed by the deer model to currently be in the stem exclusion phase because they are all over 25 years old. The deer model does not assign differing values to varying harvest levels (thinning versus clearcutting) so the model assumes that harvest of a stand will reduce the winter value to zero or nearly zero. In this case, some alternatives propose clearcutting while others propose more thinning of young growth stands. Therefore modelled differences between alternatives, especially when looking forest-wide or by biogeographic province, seem slight.

Programmatic planning at the forest level also includes evaluation of all lands suitable for harvest so the modeled habitat capability includes more harvest than is likely to occur once field reconnaissance and resource analysis are completed at the project level. At the project level, a site specific analysis can refine the projected effects of the project, including the specific stands proposed for harvest and what harvest prescriptions would be used, information on project area wildlife use and habitat conditions, and juxtaposition of those stands to each other as well as to known travel corridors.

The reason for the slight increase in the short-term is the harvest of stem exclusion phase stands which have minimal to no value in the model; the stand initiation phase these stands would be in for about the first 25 years post-harvest are modeled to have varying levels of forage value depending on other components of the model such as aspect and average snow levels. The deer model is used as a comparison tool between alternatives and represents a general trend. A 100-year rotation length is modeled, so both the 25 year post harvest (stand initiation) and 100-year post harvest (stem exclusion) phases are presented for comparison for each alternative considered in detail. The Forest Plan is intended to provide direction for 10-15 years but the model assumes the same direction (standards and guidelines) and maximum harvest rates for the full 100 years. In addition, all non-NFS lands are considered by the model to have zero winter habitat value for deer, providing a conservative estimate of habitat capability. A 250-year column would represent a return to old-growth conditions and is not necessary to present in the table as it would be similar to the original habitat capability.

All alternatives that were considered in detail were analyzed using the deer model. In depth resource analysis, such as calculating habitat capability, is not done for alternatives considered but eliminated from detailed study. Chapter 2 of the FEIS, provides the reasons for eliminating alternatives, which includes an alternative for the immediate end to old-growth logging and another for transition within 5 years.

COMMENT

DEER-5: Managing forage and habitat for the Sitka Black-tailed deer would have a positive effect on the Wolf. The Forest Service should specify an objective for improvement in winter habitat

conditions for Sitka black-tailed deer within young-growth stands on Prince of Wales Island, sufficient to offset the ongoing effects of forest succession into stem exclusion. The objective should include precommercial thinning along with other treatments.

RESPONSE

Alexander Archipelago Wolves eat a variety of prey, with Sitka black-tailed deer a primary species especially in areas where other ungulate prey is not available, such as on Prince of Wales Island. Managing for a sustainable deer population in these areas would benefit wolves, although predator-prey relationships have a number of other factors besides just the population level. In some cases, deer forage species may be increased when a young growth stand is treated (harvested) but generalizing that large clearcuts will maintain deer populations is overstating the role of one aspect of a complex population dynamic.

Deer are considered and analyzed at the project level so that site-specific factors can be considered, such as local winter habitat capability (a critical season for deer survival), levels of subsistence use in the project area, and how different habitat types are spatially arranged. An interdisciplinary resource team works together to propose projects and analyze potential effects of the project; determining the type of harvest (for example, clearcut or commercial thinning) that will best contribute toward achieving desired conditions is part of that process.

The Forest Service is actively conducting precommercial thinning on young-growth lands. Over 200,000 acres have been precommercially thinned on the Tongass since 1979. In recent years, precommercial thinning has averaged approximately 5,600 acres per year.

COMMENT

DEER-6. The Forest Service should approve actions with the least impact on Sitka Black-tailed Deer habitat. Support was expressed for the actions or alternatives with the least impact on Sitka black-tailed deer habitat.

RESPONSE

We appreciate the input provided.

Wolves (WOLF)

COMMENT

WOLF-1: Prince of Wales Wolves are in serious decline and continued logging will hasten the decline. The Forest Service must address the decline in deer winter habitat and wolves on the Prince of Wales Archipelago in the FEIS. Additionally, the Forest Service must explain whether and how the Proposed Forest Plan fulfills the agency's obligations under NFMA to ensure the viability of the wolf.

RESPONSE

See responses to WOLF-2 and DEER-5.

COMMENT

WOLF-2: The Draft Forest Plan directly violates the agency's obligation under NFMA to adopt a Forest Plan that ensures the wolf remains viable in the Tongass. The Forest Service does not disclose how much of the Tongass is not expected to meet deer habitat capability of 18 deer / square mile.

RESPONSE

Table 3.10-14 of the Draft EIS summarizes the percentage of WAAs across the Tongass that would meet the 18 deer per square mile (modeled deer density based on the interagency deer model) Wolf Standard and Guideline after implementation of the alternatives. Changes in modeled deer habitat capability by biogeographic province are presented in Table 3.10-10 under Deer, but additional information relating this to the wolf standard and guideline has been added to the FEIS in the Wolf section.

Additional information has also been added to the FEIS summarizing the findings of the recent U.S. Fish and Wildlife wolf status assessment (USFWS 2015), which notes that even with continued decline of wolves in GMU 2, viability of the species is anticipated to be maintained in Southeast Alaska. The integrity of the Tongass Conservation Strategy would be maintained by all alternatives (see FEIS Appendix D), and therefore no change is necessary to maintain a well-distributed and viable wolf population (see Forest-wide Standard and Guideline WILD1IIB).

See responses to PLR-2 and DEER-1.

COMMENT

WOLF-3: The FEIS must disclose and explain the agency's assessment of the relevant science and explain its conclusions for a viable well distributed wolf population in light of the recent USFWS Wolf Findings. The Forest Service should strengthen the plan provisions governing wolves.

RESPONSE

The FEIS has incorporated additional information related to the recent status assessment for the Alexander Archipelago Wolf (USFWS 2015).

Per Forest Plan WILD1.XIV.A.1, an interagency Wolf Technical Committee has been established and is reviewing information pertinent to wolf management. One objective is to develop recommendations for wolf and associated deer habitat management for Prince of Wales Island; findings and recommendations from their work is not yet available.

Strengthening the plan provisions governing wolves is outside of the scope of this narrow amendment. No changes to WILD1.XIV (wolf standards and guidelines) are proposed.

See also response to WOLF-2.

COMMENT

WOLF-4: The Forest Service needs to update DEIS based on USFWS Findings on the wolf.

RESPONSE

The FEIS has incorporated additional information related to the recent status assessment for the Alexander Archipelago Wolf.

COMMENT

WOLF-5: On Prince of Wales the Forest Service should develop a Wolf Habitat Management Program, reduce road densities, and avoid reducing deer habitat capabilities.

RESPONSE

Human harvest of wolves is outside the scope of the amendment. Harvest and bag limits are set by the Federal Subsistence Board and the State of Alaska Board of Game. Chapter 4 standard and guideline WILD1.XIV.A.1.c states that in areas where wolf mortality concerns have been identified and road access is a significant contributing factor that road densities of 0.7 to 1.0 mile per square mile may be necessary but the decision to close specific roads is made at the district, island, or project level through Access Travel Management plans and is based on an evaluation of all affected resources.

See responses to WOLF-2 and WOLF-3.

COMMENT

WOLF-6: The design of very large OGRs in 1997 under the Conservation Strategy was arbitrary and insufficient for sustainability or viability of wolf populations.

RESPONSE

The Conservation Strategy was implemented in 1997 as an overall conservation framework for wildlife. It provides for the diversity of plant and animal communities as required by NFMA. Redesigning the very large Old Growth Habitat reserves, one component of the Conservation Strategy, is outside the scope of this focused amendment. All alternatives maintain the integrity of the Conservation Strategy. Potential effects are discussed in Appendix D.

See also PLR-2.

COMMENT

WOLF-7: The Conservation Strategy was not revisited after the deer model was corrected.

RESPONSE

See PLR-2 regarding Conservation Strategy design.

The deer habitat suitability model is one tool used by resource managers to evaluate effects. It is used to compare the relative differences between alternatives. The model is periodically reviewed and updated to reflect current habitat relationships and modeling techniques. The design of the Conservation Strategy did not rely solely on deer habitat capability; the panel of experts considered many other factors in establishing the conservation framework to maintain viable and well distributed wildlife populations across the Tongass. Redesigning the Conservation Strategy is not part of this focused amendment.

COMMENT

WOLF-8: The 2008 and Proposed Forest Plans' wolf guidelines are unenforceable, violating NFMA by not ensuring viability.

RESPONSE

See responses to PLR-2, DEER-1, WOLF-2, and WOLF-3.

COMMENT

WOLF-9: The cumulative impacts of the alternatives to wolves and hunters were not disclosed in the DEIS.

RESPONSE

See responses to DEER-1, DEER-2, and DEER-3.

COMMENT

WOLF-10: The road density analysis for wolves was calculated using all lands when it should have included only roads below 1200 feet. High road density is a concern and should be reduced to be within the Forest Plan standard and guidelines.

RESPONSE

Road density below 1200 feet elevation has been added to the FEIS.

Appendix N of the 1997 Forest Plan FEIS explains the road density standard and guideline that is in the Forest Plan:

> The Forest Plan contains a forest-wide standard and guideline that outlines a cooperative interagency analysis to identify regions where wolf mortality is apparently excessive. In such areas we would attempt to determine if the mortality is unsustainable and identify the probable causal factors of the excessive mortality. If road access and specific roads are identified as contributing to excessive mortality, then road closures or access management recommendations can be made and actions taken. In addition, seasons, harvest methods and bag limits need to be considered as population management tools by the ADF&G and Federal Subsistence Board as a cooperative approach to managing wolf mortality at a sustainable level. The Forest Plan, a programmatic forest plan, does not prescribe a rigid open road density limit. The Wolf Assessment Panel recommended not using a specific road density "rule of thumb." This was contrary to Kirchhoff (1993) and Pletscher (1994) who recommended a road density limit of no more than one mile of open road/square mile. Appendix 13 lists WAA's that currently exceed the 0.7 mile road density identified in the Wolf Assessment and the miles of existing road that would have to be closed to reduce road densities to within these identified limits. Establishing a rigid road density level, and arbitrarily closing roads to meet this density, provides no management assurance that wolf conservation objectives would be achieved, and may unnecessarily limit overall public use of an established road system that may otherwise have no specific adverse impact on wolf mortality. Management recommendations for road and access management, if necessary, would result from the site-specific analysis discussed above that would identify a problem requiring a local and cooperative management resolution. Open road densities above or indeed below these referenced densities may be appropriate to effectively manage road-access related wolf mortality. This approach is taken by the Forest Plan.

Per Forest Plan WILD1.XIV.A.1, an interagency Wolf Technical Committee has been established and is reviewing information pertinent to wolf management on Prince of Wales Island.

COMMENT

WOLF-11: The DEIS does not consider flaws in the recent Archipelago Wolf ESA listing decision.

RESPONSE

The USFWS is the agency responsible for implementing the Endangered Species Act nationally, along with National Marine Fisheries Service for marine species. The FEIS reviewed and incorporated

information from the recent USFWS status assessment (2015) and listing decision (2016) and believes it to be the best available science.

COMMENT

WOLF-12: The Forest Plan should refer to wolves as grey or timber wolves, not Alexander Archipelago wolves.

RESPONSE

The FEIS has been updated to reflect the recent USFWS determination. No changes were made to the Forest Plan use of Alexander Archipelago wolf terminology, since this is the subspecies common name.

Goshawk (GOSH)

COMMENT

GOSH-1. The Queen Charlotte Goshawk is a sensitive species and the Forest Service must maintain viable populations and habitat distributed across the range to avoid extirpation and/or federal listing. The DEIS does not provide a meaningful analysis for goshawks that includes continued old-growth logging in addition to young growth harvest in the beach fringe, RMAs, and Old-Growth Habitat LUD; cumulative effects of NFS and non-NFS lands including the Sealaska conveyance and old-growth harvest since 2008; or at a site specific scale for high-risk VCUs. The DEIS should have responded to concerns about the adequacy of the Conservation Strategy, considered alternative nest management strategies, and manage young growth to return it to old growth conditions.

RESPONSE

A review of the potential effects to the Conservation Strategy from the amendment is presented in Appendix D, as well as discussion on habitat for species intermixed in DEIS Chapter 3 analysis of Biodiversity and Wildlife. All alternatives include a proposal to adopt the interagency recommended Old-Growth Habitat reserve modifications that were necessary as a result of the Sealaska land conveyance on Prince of Wales and surrounding islands. See also the PLR-2 response regarding the Conservation Strategy.

The 1982 Planning Rule (in effect at the time of the 1997 and 2008 Forest Plans) directed that “fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area.” The 1997 Forest Plan developed a conservation framework for wildlife that employed this now superseded regulation; this proposed amendment carries forward that Conservation Strategy and contains a goal of providing an abundance and distribution of habitats to sustain viable populations in the planning area (Tongass National Forest).

The goshawk is a Region 10 sensitive species. Goshawks are analyzed in the Biological Evaluation, available in the planning record. The DEIS provides a summary of that analysis on pages 3-211 to 3-212 and 3-240 to 3-241 in the DEIS. The finding for goshawk is “may impact individuals but would not result in loss of viability of this species or a trend toward federal listing.” This finding took into account habitat needs and proposed management activities, and Forest Plan direction for goshawks. In 2007, the USFWS confirmed the Queen Charlotte goshawk Southeast Alaska Distinct Population Segment to not be warranted for listing under the Endangered Species Act.

In addition, the 1997 and 2008 Forest Plan FEIS’s provide additional information on goshawk. These analyses included assumptions that old growth would be harvested at the maximum allowable rate under Forest Plan direction for 100 years and still found that goshawk populations would remain viable in the planning area; old growth harvest has been far less than that anticipated in those analyses. In the long-term this proposed amendment would further reduce old-growth harvest, although there is a necessary transition time until a primarily young growth harvest industry is anticipated; this is about 16 years under the preferred alternative. There is potential for short term localized disturbance to individual goshawks in beach fringe, RMAs, and Old Growth Habitat LUDs, which is taken into account in the BE finding for this species.

Tables 3.9-12and 3.9-13 display Forest-wide (range of the goshawk) by biogeographic province total POG and high-volume POG; about 91 percent total POG and about 83 percent high-volume POG are expected to remain on the Forest under the preferred alternative (Alternative 5). These provide a good estimate of goshawk preferred habitat for analysis at the programmatic (Forest Plan) level. A smaller scale taking into account site specific information is done at the project level.

The young growth proposed for harvest in the beach fringe, RMAs, and Old-Growth Habitat LUD should accelerate those stands toward old-growth conditions (desired conditions DC-YG-BEACH-01, DC-YG-RIP-01, and DC-YG-WILD-01). Forest-wide, suitable acres of young growth in beach fringe, RMA, and OG LUD are about 2 percent, 4 percent, and 3 percent of the total acres in that component, respectively.

Standards in these areas allow for a one time entry with a maximum of 10 acre openings and a maximum of 35 percent of the acres or basal area to be removed; these are the upper limits and it is unknown how often these maximums would meet the stated desired conditions. Project decisions will have to disclose how they meet plan components, including desired conditions. In addition, within Old Growth Habitat LUD, young growth treatments should emulate the natural scale and distribution of disturbance patterns (DC-YG-WILD-02). The Old-Growth Habitat LUD could also be modified using Appendix K process and criteria to eliminate young growth and gain old-growth within the reserve boundary if the interagency team thought this exchange beneficial (management approach).

Existing nest buffer standards and guidelines remain in the Forest Plan, with the clarification that if there is not 100 acres of POG available, then the largest diameter young growth may be substituted. See the GOSH-2 response.

Existing Forest Legacy standard and guideline also remains. This standard and guideline was implemented in the 2008 Forest Plan in place of a species-specific goshawk standard and guideline; this was to provide a more comprehensive approach (versus species-specific) and applies to high-risk VCUs across the Forest instead of just on Prince Of Wales Island. The proposed Forest Plan amendment clarified the existing standard and guidelines to apply to any VCU found during project level review to have POG harvest over 33 percent, not just those listed in the Forest Plan. Alternatives 3 and 4 also considered having it apply to young growth harvest in addition to old-growth harvest; this option is available to the responsible official to choose as part of the decision.

COMMENT

GOSH-2: Comment recommends updating standards for management of goshawk nesting habitat to not remove nest buffers after two years of inactivity and to incorporate post-fledging areas.

RESPONSE

Buffers for known nests remain intact; the buffers that may be removed after two years of inactivity are for probable nest stands where no nest was located / confirmed. A clarification was made to the Forest-wide Standards and Guidelines for Northern Goshawk (including the Queen Charlotte goshawk subspecies) (WILD4, II. Sensitive Species, A.1.c. Nesting Habitat) to clarify that if productive old-growth alone is not sufficient to maintain an area of not less than 100 acres around a nest, the largest diameter young-growth forest will be used. Addition of new standards and guidelines for goshawk, such as addition to management of post-fledging areas, were not included as part of this focused amendment.

COMMENT

GOSH-3. The 2008 Forest Plan FEIS (Appendix C, page C-3) concluded that the Sealaska conveyance would require a plan revision based on the changes and inability to make up lost lands in the reserve system; it is arbitrary for the agency to reverse its previous position without an adequate explanation.

RESPONSE

Although Appendix C of the 2008 Forest Plan FEIS indicated that the proposed Sealaska conveyance would require a plan revision (C-3), it also indicated this was still only proposed legislation that it was not possible to identify the types of Tongass lands and resources that would likely be affected by the proposal and “Consequently, the discussion of forest management implications for the potential conveyances is necessarily quite general” (C-2). The 2008 Record of Decision clarified this to state that “If at a later date one or both of these proposals become law, an analysis of the effects will be necessary to determine if a revision or amendment of the Forest Plan is warranted” (page 54). Thus, this amendment includes a review of the Old-Growth Habitat LUD affected by the conveyance, and proposes to adopt the interagency location for these reserves under all action alternatives (see Appendix E of the FEIS).

Prince of Wales Spruce Grouse (PGR)

COMMENT

PGR-1: The DEIS does not disclose the Proposed Forest Plan's risks to the spruce grouse. The Forest Service must explain and the FEIS must disclose whether and how the Forest Plan will ensure the continued viability of Prince of Wales spruce grouse.

RESPONSE

Alternatives are ranked in relative order (comparison) of the amount of POG they harvest (DEIS page 3-260) and thus the amount of fragmentation and potential risk to Prince of Wales Spruce Grouse. A short-term benefit from increased forage availability may occur under all alternatives.

Spruce Grouse is not a Management Indicator Species or a Region 10 sensitive species nor is it a species listed as threatened, endangered, proposed, or candidate under the Endangered Species Act. The population is large enough to support harvest (hunting). The current regulations issued from ADF&G have a harvest season of August 1 – May 15 with a bag limit of 5 grouse / day. The effects analysis acknowledges the species' susceptibility to overharvest (DEIS page 3-233). A discussion of potential effects to spruce grouse in relation to timber harvest and road development is included in the FEIS. Road closures are managed at the district / island level through the Access and Travel Management Plans.

This species is also known to use young growth forest about 15-30 years in age. Proposed young-growth harvest under the Forest Plan amendment is for commercial harvest and would be in stands older than those used by spruce grouse.

See response to PLR-2.

Crossbills (CROSS)

COMMENT

CROSS-1: The DEIS does not adequately address effects to red crossbills or recognize them as a "species of greatest conservation need."

RESPONSE

A general analysis of migratory birds was included in the DEIS, including birds that use hemlock/spruce/cedar forest as their primary habitat; individual species were not analyzed.

Red crossbill is included in the most recent Alaska Comprehensive Wildlife Conservation Strategy as a species in two species groups: a) landbirds with long-term declines and b) landbirds sensitive to forest management (ADF&G 2006, Appendix 3). Within the "landbirds with long-term declines" group, species of particular concern included the Olive-sided flycatcher, Blackpoll warbler, and Rusty blackbird; the red crossbill was identified as a species with "widespread declines but not in Alaska," approximately 5 percent of the global population estimated in Alaska, and a slightly increasing abundance trend across the state (ADF&G 2006, Appendix 4). The State of Alaska is in the process of updating the strategy; the recent Alaska Wildlife Action Plan review draft (ADF&G 2015) does not include the red crossbill on the list of "Species of Greatest Conservation Need." In addition, the 2010 Audubon Alaska "Watchlist" does not include the red crossbill on its list of Alaska species vulnerable or declining and warranting conservation attention.

Northern Flying Squirrel (NFSQ)

COMMENT

NFSQ-1: The Forest Service has not considered available information or cumulative effects on Northern Flying Squirrel.

RESPONSE

The DEIS acknowledges that flying squirrels have limited dispersal capability and that abundance may be reduced through forestry practices that reduce the structure or age of residual stands or create openings too wide (page 3-259). Some additional discussion has been added to the FEIS regarding cumulative effects to flying squirrel and flying squirrel viability.

The 1982 Planning Rule (in effect at the time of the 1997 and 2008 Forest Plans) directed that "fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area." The 1997 Forest Plan developed a conservation framework for wildlife that employed this now superseded regulation; this proposed amendment carries forward that Conservation Strategy and contains a goal of providing an abundance and distribution of habitats to sustain viable populations in the planning area (Tongass National Forest). NFMA requires forest plans to "provide for the diversity of plant and animal communities based on the suitability and capability of the specific land area." This is achieved through implementation of the Conservation Strategy and Forest Plan direction.

Kittlitz's Murrelet (KMUR)

COMMENT

KMUR-1: The DEIS does not consider effects of climate change on Kittlitz's Murrelet.

RESPONSE

The Biological Evaluation (BE) concludes that the proposed amendment may affect individuals but is not likely to cause a trend toward listing for this species (located in planning record). Page 25 of the BE acknowledges that disturbance or displacement of foraging Kittlitz's murrelets could slightly impact foraging success or energy reserves (indirect effects of associated marine traffic near young growth or renewable energy site management).

Cumulative effects for TES species are considered in the BE on pages 29-31, including a paragraph on general climate change. Climate change could affect the Kittlitz's murrelet if saltwater glaciers melt and change preferred foraging habitat or if preferred nesting habitat (unvegetated scree slopes, cliffs, rock ledges) are affected such as by vegetation encroachment; quantifiable information is not available on what those effects might be and any such effects would be distant in the future and unrelated to the Forest Plan amendment.

Marten (MART)

COMMENT

MART-1: Forest Service needs to address the status of the Pacific marten and explain how the Draft Forest Plan affects its viability in the Tongass.

RESPONSE

See response to PLR-2.

The DEIS acknowledges there are two lineages of marten in Southeast Alaska (page 3-220). The FEIS adds language regarding taxonomic uncertainty of the marten and the recent information suggesting two distinct species (Dawson and Cook 2012). Additional discussion has been added to the FEIS.

COMMENT

MART-2: The DEIS fails to meaningfully examine the impacts associated with the Draft Forest Plan's proposal to log in OGRs, beach fringe, and riparian buffers on marten.

RESPONSE

Marten are strongly associated with old growth (late successional) forest and riparian areas including the breach fringe. Only young growth harvest would be authorized in the beach fringe, riparian areas, and Old-Growth Habitat LUD under the amendment; old growth harvest would remain not suited for timber production in these areas. Young growth harvest in these areas would be aimed to accelerate old growth conditions in these areas under the preferred alternative (desired conditions), which should benefit marten. Alternatives 3 and 4 consider implementing legacy standards in young growth harvest; all alternatives would evaluate landscape connectivity among reserves during project analysis.

All alternatives provide old growth no-harvest buffers along Class I, II, and III streams. TTRA directs that no commercial timber harvest is allowed within a minimum of 100 feet horizontal distance either side of Class I streams and Class II streams that flow directly into a Class I stream. Alternative 5 allows up to 10 acre openings and commercial thinning totaling no more than 35 percent of the total stand acres in beach fringe, RMA, and Old-Growth Habitat LUD, and will only occur in the first 15 years of the finalization of the Plan Amendment; it is estimated to be about 3,500 acres of beach fringe, 900 acres of total harvested RMA area, and 1,800 acres of Old-Growth Habitat LUD. With these restrictions, the overall areas affected would be small relative to the total beach, RMA, and Old-Growth Habitat LUD acres in the Tongass.

COMMENT

MART-3: The DEIS misses important recent information (Goldstein et al. 2013[3]) that marten use young growth and did not evaluate viability.

RESPONSE

See response to PLR-2.

Additional information on marten use of young growth habitat and marten viability has been updated in the FEIS.

The marten effects analysis in the DEIS focuses on old-growth (POG) timber harvest because 1) the strong association of marten with structural complexity typically found in old-growth forest, 2) the importance of low elevation high volume POG to marten in winter, and 3) preference for landscapes with forest interior habitat conditions. However, DEIS page 3-250 acknowledges that both old-growth and young-growth harvest would reduce the vertical and horizontal structural complexity needed by marten.

[3] Goldstein, M.I., L.H. Suring, C.D. Vojta, M.M. Rowland, and C. McCarthy. 2013. Developing a Habitat Monitoring Program: Three Examples from National Forest Planning. *in* USDA Forest Service. 2013. A Technical Guide for Monitoring Wildlife Habitat. GTR-WO-89.

In addition, road density is displayed in Table 3.10-12 for NFS lands and for all ownerships. Under the preferred alternative about 12 percent of the WAAs on the Forest would exceed 1 mile per square mile road density for all roads, with less than 3 percent of WAAs exceeding that when open roads on NFS lands are considered.

Alternatives 3 and 4 considered applying legacy forest structure during young growth harvest in those high risk VCUs listed in WILD1.IV; this demonstrates consideration of science indicating marten's use of young growth. This option is available for the responsible official to choose as part of the decision.

The 1982 Planning Rule (in effect at the time of the 1997 and 2008 Forest Plans) directed that "fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area." The 1997 Forest Plan developed a conservation framework for wildlife that employed this now superseded regulation; this proposed amendment carries forward that Conservation Strategy and contains a goal of providing an abundance and distribution of habitats to sustain viable populations in the planning area (Tongass National Forest).

Black Bear (BLABE)

COMMENT

BLABE-1: The DEIS's cursory analysis of black bears does not rise to the level of a hard look required by NEPA and the Forest Service should employ the 2012 Planning Rule.

RESPONSE

Black bears need old growth forest for denning but during the spring and summer seasons use a variety of habitats, including young clearcuts. Anadromous (Class I) streams are important to bears in the late summer as they build fat reserves for hibernation; these are protected from harvest under the proposed amendment. Inventoried Roadless Areas will also provide areas of undisturbed habitat for black bears beyond what was anticipated during the 1997 Forest Plan viability analyses. Large and medium reserves are also not scheduled for harvest; small reserves may have up to 35 percent of the young growth harvested but the reserve may be modified at the project level to exclude the proposed harvest and replace it with old growth if the interagency team proposes such modification. The black bear population in much of southeast Alaska appears stable (ADFG 2015[4]).

All alternatives provide old growth no-harvest buffers along Class I, II, and III streams. TTRA directs that no commercial timber harvest is allowed within a minimum of 100 feet horizontal distance either side of Class I streams and Class II streams that flow directly into a Class I stream. While Alternative 5 allows up to 10 acre openings and commercial thinning totaling no more than 35 percent of the total stand acres, it is estimated to be about 900 acres of total harvested RMA area and will only occur in the first 15 years of the finalization of the Plan Amendment. With these restrictions, the overall areas affected would be small relative to the total RMA acres in the Tongass.

See also PLR-2.

[4] ADF&G. 2015. Black Bear Management Report. Individual Game Management Unit (GMU) reports for GMUs 1A, 1B, 1C, 1D, 2, 3, and 5 were accessed at http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20145

Brown Bear (BROBE)

COMMENT

BROBE-1: The DEIS needs to analyze Brown Bear effects more fully and use the 2012 Planning Rule.

RESPONSE

Brown bears do need large areas of undisturbed habitat. Additional undisturbed habitat beyond the 1997 and 2008 analyses will be maintained in Inventoried Roadless Areas in the future; no young growth or old growth harvest will take place in these areas under the selected alternative. Young growth harvest that would be available for harvest in the Old Growth Habitat LUD is primarily located in small reserves near current development LUDs, not in the medium and large reserves that are more important for brown bears. Much of the prime brown bear habitat on the Forest is located in areas protected by the Forest Plan – Wilderness, LUD II, and other non-development LUDs on the mainland, Admiralty and Baranof Islands, and portions of Chichagof Island. Prince of Wales Island contains a large portion of the young growth that would be harvested under the amended Forest Plan; no brown bears persist on this island which further reduces risk to the species.

All alternatives provide old growth no-harvest buffers along Class I, II, and III streams. TTRA directs that no commercial timber harvest is allowed within a minimum of 100 feet horizontal distance either side of Class I streams and Class II streams that flow directly into a Class I stream. While Alternative 5 allows up to 10 acre openings and commercial thinning totaling no more than 35 percent of the total stand acres, it is estimated to be about 900 acres of total harvested RMA area and will only occur in the first 15 years of the finalization of the Plan Amendment. With these restrictions, the overall areas affected would be small relative to the total RMA acres in the Tongass.

See also PLR-1 and PLR-2.

Bats (BAT)

COMMENT

BAT-1: The DEIS fails to consider or disclose impacts on Keen's Myotis and other bat species.

RESPONSE

Seven species of bats are known to occur in Alaska; all but the little brown bat is restricted to Southeast Alaska (http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.batsinak). Bats occur in low densities in Alaska, and distribution, abundance, and behavior are poorly understood; ADF&G has ongoing research and monitoring efforts to learn more about the bats in Alaska (http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.bats). Timber harvest may be a threat to little brown bats, but activity was rare in young growth forest (http://www.adfg.alaska.gov/index.cfm?adfg=littlebrownbat.main). Across North America, large scale wind energy developments and White-Nose Syndrome (a fungal infection) are causing high mortality of bats. White-Nose Syndrome has not been documented in Alaska; the nearest known location is a recent confirmed infection in Washington state (http://www.usgs.gov/newsroom/article.asp?ID=4496#.Vww6GnL2ZMw). The Draft Forest Plan is not proposing to harvest old-growth in riparian management areas (RMAs) but may have limited young-growth harvest in these RMAs; bat activity in young growth is low.

Amphibians (AMPH)

COMMENT

AMPH-1: The Forest Service must include an analysis of potential impacts on amphibians from logging and roads.

RESPONSE

A discussion of amphibians has been added to the Final EIS. This includes a discussion of those species potentially present on the Tongass, as well as potential effects associated with old-growth and young-growth timber harvest such as fragmentation, road mortality, exposure to contaminants along roads, and cumulative effects associated with climate change.

Possible effects to riparian areas, which could influence amphibians survival and production, are also disclosed in the FEIS in the *Water, Wetlands*, and *Fish* sections.

COMMENT

AMPH-2: Amphibians are especially susceptible to air pollution.

Because amphibians' skin is permeable, they are especially susceptible to the harmful effects of air pollution. Atmospheric contaminants such as acidic compounds may also be deposited in aquatic ecosystems where amphibians live. In Southeast Alaska, air pollution from local or global sources may be contributing to a decline in amphibians' numbers.

The DEIS predicts that "direct effects on air quality from forest management activities would be temporary and limited in nature" and may include emissions from industrial processing sites and firewood burning. It also notes that, cumulatively, air pollution from wood processing could "increase somewhat if more wood is burned to produce energy." The Forest Service should consider the potential consequences of worsened air quality for amphibians in the FEIS, in light of their sensitivity to this kind of pollution.

RESPONSE

None of the alternatives are expected to result in long-term adverse impacts to air quality or compliance with air quality standards. All air quality effects associated with equipment usage, wood processing, etc. would be temporary and localized, and would occur infrequently over the planning horizon. Therefore, no effects to amphibians are anticipated in association with reduced air quality.

Subsistence (SUB)

COMMENT

SUB-1: The Forest Service must engage communities to identify and prioritize restoration areas that will enhance local subsistence opportunities.

RESPONSE

Prioritizing restoration treatments is done at a scale smaller (districts and project level) than the Forest Plan. During every EIS the Forest Service holds subsistence hearings as required by ANILCA section 810 in addition to public scoping and comment periods. These provide opportunities for communities, tribal members, subsistence users, and others to speak specifically to project effects to subsistence use.

COMMENT

SUB-2: The treatment of subsistence deer hunting in the DEIS is arbitrary and masks local impacts to abundance and distribution of subsistence resources.

RESPONSE

At the programmatic level (Forest Plan), the DEIS conclusion of a significant possibility of a significant restriction on subsistence uses, particularly for deer, acknowledges that cumulatively across the Forest there could be areas where subsistence uses may be impacted. Each project that uses an EIS must hold a subsistence hearing to determine whether the project would have a significant possibility of a significant restriction on subsistence uses. This allows for site specific information to be used in the analysis such as what subsistence resources occur in the project area and may be affected, what levels of use occur in the project area by subsistence and non-subsistence users, and for subsistence users of the project area to tell managers what impacts the project may have on them. Subsistence uses would be given preference over non-subsistence uses if any restrictions are determined necessary. The Forest Plan determined an overall possible risk while project-level subsistence evaluations better identify specific impacts to abundance and distribution, access to resources, and competition with non-rural users.

COMMENT

SUB-3: The Forest Service should conduct a more thorough ANILCA Section 810 Analysis.

RESPONSE

Each project that requires an EIS must hold a subsistence hearing (ANILCA 810(b)) to determine whether the project would have a significant possibility of a significant restriction on subsistence uses. Individual projects are not proposed at the programmatic level; the Forest Plan subsistence analysis acknowledges that cumulatively across the Forest there could be areas where subsistence uses may be impacted (makes a finding that a significant possibility of a significant restriction on subsistence uses, particularly for deer, may occur when the Forest Plan is fully implemented). Subsistence hearings were held across the Forest during the comment period. Site specific information such as what subsistence resources occur in the project area and may be affected, what levels of use occur in the project area by subsistence and non-subsistence users, and for subsistence users of the project area to tell managers what impacts the project may have on them would be incorporated in to ANILCA 810 analysis at the project level.

COMMENT

SUB-4: The Forest Service should include greater protections for subsistence uses and hunting in the Plan, especially in areas already highly impacted by past practices.

Changes to subsistence standards and guidelines (Chapters 3 and 4 of the Plan) are outside the scope of this focused plan amendment.

Karst (KARS)

COMMENT

KARS-1: The DEIS does not adequately disclose the effects of changes to the degree and methods of logging permitted in karst lands. Some suggest that forest management activities should not take place in and around sensitive karst landscapes.

RESPONSE

The DEIS does not allow for any less restrictive methods of timber management on karst lands than from those in the 2008 Forest Plan. The 2008 Forest Plan, Appendix H, V. Young-Growth Management on Karst, Page H-8 states that; "Commercial thinning is appropriate on low to moderate vulnerability karst lands when the karst management objectives can be met. Generally, no thinning shall be permitted on lands determined to be of high vulnerability such as within 100 feet of a cave entrance, a karst feature accepting surface flow, or of the edge of a sinking or losing stream within 0.25 mile upstream of their swallow hole or loss point. On a case-by-case basis, other karst features will be assessed as to their susceptibility to surface disturbing activities, the proposed harvest method, and the thinning prescription. The area surrounding these features is still considered high vulnerability and should be mapped as such; however, thinning of this sensitive area might be considered permissible. All features not fully protected would be buffered from their center to just outside the lip of the sink allowing for thinning within the area that would normally be a non-harvest buffer. It is probable that a zone equal to one tree height be left untreated to ensure that no material will be placed in these features. All thinned timber will be directionally felled from the untreated area surrounding the karst feature and split yarded from the area. Any material landing on the slope break of the feature or within the feature will be hand removed. No yarding across or through the untreated area surrounding the feature will be allowed. Directional falling and split yarding away from the karst depressions and features should provide adequate protection for water quality and karst features. It is believed that the benefit of hydrologic recovery of the areas adjacent to these features outweighs the risk of harvest. Again this should be assessed on a case-by-case basis."

The same process for assessing the vulnerability of karst lands and determining appropriate timber management methods exist in the DEIS. Even-aged management on low vulnerability karst and limited clear-cutting in medium vulnerability karst has always been allowed, although more restrictive guidelines than normally employed on non-karst lands may be needed on medium vulnerability karst. Alternatives 1 through 4 would be managed in similar fashion so long as karst management objectives could be met. Under Alternative 5, created openings are limited to 10 acres with a maximum removal of 35 percent of the original stand. Project-specific karst evaluations would still be required and effects would be avoided or minimized through project and site specific management prescriptions, such as requiring partial suspension yarding or limiting the size of openings moderate changes to precipitation throughfall.

The Tongass is not opening up all high vulnerability karst areas to timber management. There would be no additional harvest in any areas mapped as high vulnerability karst under Alternatives 1 and 5. Alternatives 2, 3, and 4 each allow for commercial thinning on high vulnerability karst on a case-by-case basis when the karst management objectives can be met (Draft DEIS, p. 3-33, paragraph 1). Alternatives 2, 3, and 4 each allow for commercial thinning on high vulnerability karst lands but does not guarantee it. Based on our experience, we believe that carefully planned and implemented commercial thinning of young growth stands on high vulnerability karts can be neutral or even beneficial to the karsts, where appropriate.

We believe the activities discussed above could be implemented with careful planning. We also recognize the shortage of monitoring on the effects to karst from second growth management and acknowledge there is some uncertainty. However, at the project-scale, karst resources will continue to be evaluated and effects from harvests on medium and high vulnerability karst lands will be addressed through project-specific prescriptions.

Low vulnerability karst lands are not sensitive to management activities due to the depth of overlying material (e.g. glacial till) and low hydrologic conductivity. There would be no change to management practices on these lands between any alternatives.

Text has been added to the Karst section of Chapter 3.

COMMENT

KARS-2: The Forest Plan should clarify how young-growth stands in Geologic Special Interest Areas can be managed (See Timber Resource Planning TIM4) and the Kruzof Geological special interest area should be designated as a National Monument with no harvest.

RESPONSE

Many of the Geologic Special Interest Areas created for their intensity of karst development contain areas of past harvest. We recognize the sensitivity of these areas to disturbance, timber management, and road construction. However, we believe that careful commercial thinning of some of the young-growth stands in these areas should be considered when karst and cave resource values are not compromised. Preliminary data (Prussian, 2011) does support the concept that commercial thinning of the older young-growth stands on karst, returning the stand to closer-to-pre-harvest tree spacing, hastens the hydrologic recovery of the site. Reducing the canopy cover could restore the 'health' of young growth forests on karst lands by increasing the volume of throughfall, flushing sedimentation out of diffuse and discrete karst openings, and reconnecting surface to subsurface flow pathways. The management of older young-growth stands can also hasten the return to more natural stand characteristics and conditions.

Thinning of heavily stocked young-growth stands can increase tree growth, improve stand stability and health of the trees, and increase the amount of light and rainfall that reaches the understory. These may benefit areas of karst that were previously harvested. Some treatments may be prescribed on karst areas where it is determined, through site specific analysis, that it could benefit the resource and not compromise or damage the karst resource.

Designation of the National Monuments are outside of the scope of this amendment and the authority of the Responsible Official.

COMMENT

KARS-3: The Forest Plan should address active management of young growth stands in Karst formations and how harvest should be accomplished to minimize any negative impacts while generating volume.

RESPONSE

The young-growth plan components in Chapter 5 ensure that karst ecosystems "maintain natural processes and productivity, while providing for other land uses." (See desired condition DC-YG-KC-01 in Chapter 5.) Alternatives 2, 3 and 4 include young-growth standard S-YG-KC-01 that allows commercial thinning on high vulnerability karst on a case-by-case basis (DEIS, Appendix F). The management approach for karst and cave resources in Chapter 5 also provides direction to evaluate karst vulnerability.

COMMENT

KARS-4: Alternative 3 should prohibit commercial timber harvest on High Vulnerability Karst.

RESPONSE

The range of alternatives analyzed in detail included support these and other goals to varying degrees. Table 2-17 in Chapter 2 shows that Alternatives 1 and 5 (preferred alternative) do not allow commercial timber harvest on high vulnerability karst while Alternatives 2, 3, and 4 allow commercial thinning.

See response to KARS-1.

COMMENT

KARST-5: High-vulnerability karstlands should be fully protected from timber harvest. The prescriptions available for medium-vulnerability karstlands should be limited.

RESPONSE

Among the five alternatives, some allow no entry into high-vulnerability karst and some allow commercial thinning only. No specific additional restrictions are added for moderate vulnerability karst; however, many of the existing Forest-wide standards and guidelines are specific to moderate vulnerability karstlands.

Road Density (RD)

COMMENT

The Forest Service needs to actively reduce road densities, stop wolf harvest, and end old-growth clearcutting to save wolves.

RESPONSE

Wolf harvest bag limits are not within the scope of the Forest Plan amendment. The Federal Subsistence Board works with the State of Alaska Board of Game to set seasons and bag limits for subsistence and sport harvest.

Specific harvest prescriptions, such as even-aged management, are determined at the project level, not the programmatic Forest Plan level, after a review of each stand's goals, needs, and resource concerns. See also TIM-13.

Young growth harvest within the Old-Growth Habitat LUD could require roads to be constructed but that would depend on site-specific conditions such as existing access and the harvest prescription for the stand. When young-growth harvest is proposed within an Old-Growth Habitat LUD, an interagency biologist team would review the location and design of the reserve and could recommend a modification to the LUD boundaries to exclude the young-growth stand to be harvested if adjacent old-growth could be added and if it would better meet the criteria in Forest Plan Appendix K.

Road density is evaluated as part of project planning; site specific resource concerns are identified and evaluated during that process. Access Travel Management plans and road maintenance objectives are generally reviewed during each project as well. Often, road closures for existing roads are prioritized based on funding, resource concerns, and access needs for resource management activities; closed roads (ML1) may or may not be physically barricaded but are not open for public use.

COMMENT

RD-2: Forest Service has not Fulfilled Road Density Goals in the 2008 Plan for wolf populations and does not identify where several WAAs exceed 0.7 mile per square mile.

RESPONSE

Table 3.10-4 in the DEIS displays road density for all roads and for open roads, both on NFS lands only and for all land ownerships. Average road density across all Wildlife Analysis Areas (WAAs) is provided in the FEIS. WILD1.XIV.A.1(c) includes a total road density of 0.7 to 1.0 miles per square mile in areas where wolf mortality concerns have been identified and road access was determined to be a significant contributing factor; not all WAAs are required to have road densities less than 0.7 miles per square mile. Resource concerns, such as road density, are evaluated at the project level; decisions under the amended Forest Plan are required to say how they meet the plan components which include standards and desired conditions. See also RD-1.

An interagency Wolf Technical Committee has been established and is currently working on wolf management concerns on Prince of Wales Island. Findings and recommendations of that committee are not yet available.

COMMENT

RD-3: The Plan Amendment should bring greater clarity to the road density issue by defining the various terms for Tongass road closures. The Plan Amendment does not presently define "open road," "closed road," and "decommissioned road." (See Plan Amendment Glossary for lack of definitions for these terms; although "open road mileage" is defined, "open road" is not).

RESPONSE

Maintenance Level 1 (ML1) roads are considered closed (Transportation section DEIS page 3-273); open roads are roads in ML 2-5. Closed roads may or may not be physically blocked but use is illegal on roads designated as ML 1 status; these roads do not show up on the Motor Vehicle Use Maps available to the public. The Table 3.10-4 in the DEIS displays road density for all roads and for open roads, both on NFS lands only and for all land ownerships. In the FEIS, this table has been expanded to include a break down by Wildlife Analysis Area (WAA). Pages 3-224 to 225 in the DEIS include information on wolf harvest and the role of road access in that harvest, and acknowledges possible consequences of such harvest vulnerability. The Forest Plan Glossary has been updated to clarify that roads in ML 2-5 are considered when calculating open road density.

COMMENT

RD-4: The Forest Service should add a standard and guideline in its Transportation System Corridors direction to maintain Tongass WAAs at a threshold of 0.7 mi/mi2. WAAs that presently exceed the 0.7 mi/mi^2 threshold should have no net gain in roads (new road additions should be countered by road closures/decommissioning). WAAs that exceed 1.0 mi/mi^2 should receive priority efforts to reduce road densities.

RESPONSE

Standards and Guidelines are included under the primary resource that is driving that particular standard. In this case, the suggested standard and guideline are primarily a wildlife concern not a transportation concern. WILD1.XIV.A.1(c) on page 4-88 includes a similar road density (total road density of 0.7 to 1.0 miles per square mile) in areas where wolf mortality concerns have been identified and road access was determined to be a significant contributing factor. An interagency Wolf Technical Committee has been established and is currently working on issues related to wolf management concerns on Prince of Wales Island.

Access Travel Management plans are completed at the island, district, or project levels to allow for more localized analysis of road densities in relation to resource concerns and which roads are needed to access areas for resource management (or those that are not needed which can be closed). In addition, road closures are prioritized based on financial constraints in addition to resource concerns.

COMMENT

RD-5: We are concerned that the cumulative effects on transportation arising from the inter-linkage of logging road systems, is not disclosed or considered in the EIS. Important choices are being made without benefit of good information.

RESPONSE

The DEIS/FEIS adequately discloses the effects of roads. In the affected environment sections the cumulative effects of all existing roads, including open, closed, and decommissioned roads, are addressed. In the effects sections, the assessments include the estimated future roads on NFS lands and on non-NFS lands over a 100-year period.

COMMENT

RD-6: The extent of sediment delivery from roads that results from construction, reconstruction, and storage of logging roads is not well addressed. Increased use of roads also has the effect of increasing sediment delivery to streams. Many studies show increased logging traffic elevates sediment delivery to streams.

The DEIS seems to suggest the agency is using the road storage strategy as a back-door way to avoid complying with the Clean Water Act, rather than as a considered transportation strategy. Where a road truly is justified, the best public interest seems to be met by just building and properly maintaining that road. The second-growth transition provides an opportunity to focus

logging in fewer areas, which means fewer roads should be need to access them, and so a straight-forward road management strategy becomes increasingly more affordable and desirable.

RESPONSE

The DEIS recognizes that roads are a major source of resource effects. The Water and Fish sections provide extensive analysis and quantification of road effects on streams and fish, including sediment effects. The analysis addresses existing roads, stored roads, decommissioned roads, reconstructed roads, and new roads.

Road storage is a management tool to reduce long-term costs, by minimizing road maintenance costs, and reducing effects on streams and fish. If a road is important for recreation or other purposes, it is managed differently. Storage, which results in road closure, also helps address potential effects on wolves, by reducing access. Most roads accessing young-growth stands will not be needed, after harvest, for many decades.

Transportation and Utility System LUD Overlay (TUS)

COMMENT

TUS-1: The amended plan should reinstate the Transportation and Utility Systems LUD overlay and the "windows" and "avoidance" language because it discouraged road building in Wilderness LUDs and some non-development LUDs, and required transportation projects to first consider feasible alternatives. The Forest Service should either reinstate the overlay, or add new direction for completing a transportation avoidance analysis in the same LUDs where the overlay applied in the 2008 Forest Plan.

RESPONSE

The intent of the Forest Plan direction for transportation systems corridors is not to change the process the Forest Service will go through when developing future transportation systems. The purpose of the plan direction for transportation systems corridors is the same as the 2008 TUS LUD management prescription; to facilitate the availability of National Forest System land for the development of existing and future transportation systems such as those identified by the State of Alaska in the current version of the Southeast Alaska Transportation Plan (SATP) and applicable laws. (See Forest Plan Chapter 5.) The applicable Transportation Systems Corridors direction in Chapter 5 is included for each LUD in Chapter 3 in a table that cross-references, by category, the plan content, found in Chapter 5.

When developing future transportation systems, the project must be designed to be consistent with the applicable plan direction. For example, Forest-wide desired condition DC-02:

> Transportation systems support community resilience, resource management, and provide for current and future land management needs, subject to applicable laws. Transportation systems avoid, minimize, or mitigate adverse effects to natural and cultural resources.

The decision document (Decision Memo, Decision Notice, Record of Decision) for a transportation activity or project must describe how the project or activity is consistent with DC-02 and other applicable plan direction, and this process is described in the *Project Consistency Requirements* section in Chapter 6 of the Forest Plan.

The Forest Service will continue projects and activities under the direction in Chapters 2, 3 and 4. The Chapter 5 plan direction for Transportation Systems Corridors will take precedence only in the event of conflicting direction. (See Priority of Direction section in Chapter 1 in Forest Plan.) If there is no direction in Chapter 5 on a specific forest resource, then Chapter 3 direction takes precedence for that resource.

The following language was added to the Forest Plan in Chapter 1, Priority of Direction:

> Chapter 5 assumes all laws, regulations, and policy pertaining to management of National Forest resources will be followed. Ground-disturbing projects will use the approved best management practices (BMPs) (National Core BMP Technical Guide FS-990a and Alaska Region Soil and Water Conservation Handbook, FSH 2509.22) to avoid, minimize, or mitigate environmental impacts.

COMMENT

TUS-2: Removal of Transportation and Utility System LUD should not be done under an amendment. A change of this nature should be done through the Forest Plan revision process described in 36 CFR 219.7 rather than the amendment process set forth in 36 CFR 219.13.

RESPONSE

The Notice of Intent (NOI) that was published on May 27, 2014 in the Federal Register (79 FR 30074) stated under the "Purpose and Need for Action" that [the Forest Service] will also evaluate other changes suggested in the 5-year review. Concerns were consistently expressed during the Five-Year Review of the 2008 Forest Plan regarding the impact of high fossil fuel prices; the adverse effect of high energy costs on economic diversification and sustainable economic development; and increasing climate change

on the quality of life in Southeast Alaska. Concerns were also expressed that the 2008 Plan's direction regarding transportation and utility systems, including the Transportation and Utility System (TUS) overlay Land Use Designation (LUD), were overly complex, confusing, and difficult to implement, creating an impediment to development of hydropower, other types of renewable energy, and transmission lines needed to connect communities to sources of electric power. Based on this review, the responsible official determined to propose changes to the Forest Plan to make the development of renewable energy resources more permissible -- including allowing greater project-level consideration of transportation and utility corridors and removing the TUS overlay LUD -- to facilitate renewable energy development in Southeast Alaska communities, provide low-carbon energy alternatives, and reduce the use of fossil fuels.

Removing the existing Transportation and Utility System LUD through a plan amendment is permissible. The last sentence of 36 CFR 219.13(a) states that: "Except as provided by paragraph (c) of this section [regarding administrative changes], a plan amendment is required to add, modify, or remove one or more plan components, or to change how or where one or more plan components apply to all or part of the plan area (including management areas or geographic areas)." (Emphasis added.) The Department added the phrase "including management areas or geographic areas" to the final planning rule to clarify that an amendment is required for any change in how or whether plan components apply to those areas (77 FR 21238). An amendment may remove all the plan components within a LUD and remove the LUD itself.

See responses to P&N-2 and PLR-1.

COMMENT

TUS-3: The Forest Service should clarify that the transportation systems corridors direction in Chapter 5 of the Forest Plan applies to major roads only and not to all roads, such as those defined in Chapter 7 (Glossary) under the term "Forest transportation system. This clarification is needed because removal of the Transportation and Utility Systems LUD leaves a gap in that major public roads would otherwise receive special consideration under the 2008 Forest Plan. The Forest Service should clarify in both the FEIS and the Forest Plan that any new transportation direction applies only to major roads.

RESPONSE

The management prescription goal in the 2008 Transportation and Utility Systems LUD, and the purpose of the plan direction for transportation systems corridors in Chapter 5 is to facilitate the availability of National Forest System land for the development of major roads; existing and future transportation systems such as those identified by the State of Alaska in the current version of the Southeast Alaska Transportation Plan (SATP) and applicable laws. (See page 5-13 of the Proposed Forest Plan Chapter 5 for this description.) The transportation systems corridors direction in Chapter 5, including Forest-wide plan components DC-02, DC-03 and DC-04, was written with this purpose in mind.

The transportation systems corridor direction is not intended to address the forest transportation system, which is defined in the glossary in Chapter 7 as "[t]he system of National Forest System (NFS) roads, trails, and airfields on NFS lands (36 CFR 212.1)." The Transportation section in Chapter 3 of the FEIS describes both major roads and forest transportation systems. (See subsections for Regional Transportation System and National Forest System Roads.) Forest-wide transportation standards and guidelines were included in the Proposed Forest Plan on pages 4-74 through 4-80. The Proposed Forest Plan also included standards and guidelines that describe Transportation Planning in TRAN 3, and the maintenance levels in TRAN 6 & TRAN 7. The first part of the following standard and guideline TRAN4 I. D. was removed in the Proposed Forest Plan:

> D. Cooperate with the Alaska Department of Transportation and Public Facilities and the Federal Highway Administration in the administration of the Forest Highway Program. Provide nominations of routes to be upgraded and encourage their transfer to state jurisdiction, in order to provide safe facilities and adequate maintenance between communities linked by the Forest Transportation System. (Consult FSM 7700.) (emphasis added)

This standard and guideline has been added back into the Forest Plan and was clarified. It now reads as follows:

> D. Cooperate with the Alaska Department of Transportation and Public Facilities and the Federal Highway Administration in the administration of the Federal Highway Programs. Provide nominations of routes to be upgraded and encourage their transfer to state jurisdiction, in order to provide safe facilities and adequate maintenance between communities linked by the Forest Transportation System. (Consult FSM 7700.) (emphasis added)

A discussion about the Southeast Alaska Transportation Plan (SATP) was included in Chapter 3 of the DEIS in the Transportation section on pages 3-271 to 3-273. The 2004 SATP was incorporated into the 2008 Forest Plan and direction was provided for it in the Transportation and Utility LUD. A draft SAPT was published in June 2014 (ADOT&PF 2014), and the DEIS provided a description of the intent of the road construction to provide access to NFS lands. Because the Proposed Forest Plan removed the Transportation and Utility Systems LUD, the SATP was incorporated into the Proposed Forest Plan and direction for it was provided in the transportation systems corridors direction in Chapter 5.

The Transportation environmental consequences section in Chapter 3 of the DEIS disclosed the following on p. 3-277:

> "Proposed new plan components for Transportation Systems Corridors (TSC) would replace the direction currently found in the Transportation and Utility System LUD. TSC plan components apply only to major road systems such as state and federal highways, railroads, and those identified by the State of Alaska in the current version of the SATP and applicable laws (for example, Section 4407 of Public Law 109-59, Title XI of the Alaska National Interest Lands Conservation Act, Public Law 96-487)… When planning future transportation projects, these plan components would apply. Prior to this, all other applicable Forest Plan LUD direction would remain in effect." (emphasis added)

COMMENT

TUS-4: The Proposed Forest Plan does not clearly indicate how the transportation systems corridors direction for major roads in Chapter 5 is to be applied with other LUD restrictions governing roads. Removal of the "avoidance area" and "window" designations in the Proposed Forest Plan makes it easier to build projects, eliminating a protective barrier to siting major roads on the majority of the Tongass. The DEIS does not disclose this change, or analyze its significant environmental effects or compliance with NFMA. Therefore, the Forest Service should make it explicit that major roads are subject to Chapter 3 road restrictions for individual LUDs in the Proposed Forest Plan.

RESPONSE

In the introduction to Chapter 5 of the Proposed Forest Plan, an explanation was provided stating that "[a] plan amendment is required to add, modify, or remove existing plan direction, or to change how or where one or more plan components apply to all or part of the plan area (including Land Use Designations) (36 CFR 219.13(a))." On page 5-3 of the Proposed Forest Plan under the section entitled "Changes Made in the 2008 Forest Plan" the Forest Service disclosed the following:

> The Transportation and Utility System overlay LUD was removed, as well as all associated direction (i.e., "window" and "avoidance area") in the LUD Standards and Guidelines pertaining to application of this overlay LUD. No other LUDs were removed. Other LUD boundaries were modified to reflect changes since 2008.

Removal of the TUS overlay LUD was also disclosed in Chapter 2 of the DEIS on p. 2-10 under the section entitled, "Proposed LUD Changes Common to the Action Alternatives."

The management prescription in the 2008 Transportation and Utility Systems LUD, and the purpose of the plan direction for transportation systems corridors in Chapter 5 is to facilitate the availability of

National Forest System land for the development of major roads; existing and future transportation systems such as those identified by the State of Alaska in the current version of the Southeast Alaska Transportation Plan (SATP) and applicable laws. (See page 5-13 of the Proposed Forest Plan Chapter 5 for this description.) The transportation systems corridors direction in Chapter 5, including Forest-wide plan components DC-02, DC-03 and DC-04, was written with this purpose in mind.

The Introduction to Chapter 3 of the Proposed Forest Plan explained how the plan direction for transportation systems corridors in Chapter 5, is applied to the LUDs by the table that cross-references the applicable direction that applies to the LUD.

When developing future transportation systems corridors, the project must be designed to be consistent with the applicable plan direction. For example, development of a major road must be consistent with forest-wide desired condition DC-02:

> Transportation systems support community resilience, resource management, and provide for current and future land management needs, subject to applicable laws. Transportation systems avoid, minimize, or mitigate adverse effects to natural and cultural resources.

The Forest Service will continue projects and activities under the direction in Chapters 2, 3 and 4. The Chapter 5 plan direction for transportation systems corridors will take precedence only in the event of conflicting direction. (See Priority of Direction section in Chapter 1 in Forest Plan.) If there is no direction in Chapter 5 on a specific forest resource, then Chapter 3 direction takes precedence for that resource.

See responses to PLR-1 and TUS-1 regarding NFMA compliance.

COMMENT

TUS-5: The Forest Service must make the Chapter 5 plan direction for transportation systems corridors clearer, since the direction in Chapter 5 will have priority over all other plan direction in Chapters 3 and 4 if a conflict or discrepancy in directions occur. The Forest Service must thoroughly explain what will constitute a conflict in this context, describe the extent of potential conflicts, and provide examples of the circumstances under which Chapter 5 direction would or would not have priority over direction in Chapters 3 and 4. The Old Growth Habitat LUD direction in Chapter 3 precludes roads unless there is no feasible alternative, but Chapter 5 transportation systems corridors direction applies to the Old Growth Habitat LUD, which allows the Forest Service to build a major road for which there may be a feasible alternative. The Forest Service has failed to disclose its obligations under NEPA and NFMA with respect to the transportation changes.

RESPONSE

The Forest Service Handbook ([FSH] 1909.12, chapter 20, section 22.2) indicates that if a plan has direction that overlaps, the plan must clearly explain which direction has priority. The explanation regarding priority is located in Chapter 1 of the Forest Plan, in the Priority of Plan Direction section, as well as in the introduction section in Chapter 5.

Until the Forest Service implements this new direction on a site-specific transportation project, providing examples of conflicts of direction, or describing the extent of potential conflicts is not warranted at a programmatic level. When developing future transportation systems, the project must be designed to be consistent with the applicable plan direction in Chapter 5. For example, wildlife standard S-TCS-WILD-01, and forest-wide desired condition DC-02.

> S-TSC-WILD-01: Design and construct transportation systems to maintain wildlife habitat corridors between old-growth reserves (OGRs), riparian management areas (RMAs), and beach and estuary fringe.
>
> DC-02: Transportation systems support community resilience, resource management, and provide for current and future land management needs, subject to applicable laws.

> Transportation systems avoid, minimize, or mitigate adverse effects to natural and cultural resources.

The decision document (Decision Memo, Decision Notice, Record of Decision) for the project or activity must describe how the project or activity is consistent with S-TSC-WILD-01, DC-02, and other applicable plan direction, and this process is described in the Project Consistency Requirements section in Chapter 6 of the Forest Plan.

On p. 3-277 of the DEIS in the Transportation environmental consequences section, the Forest Service disclosed that under the action alternatives:

> "With this amendment, the existing transportation and utility LUD and avoidance areas would be removed from the Forest Plan. TSC plan components, e.g., standards and guidelines to the Forest Plan, would take precedence over other forest-wide and LUD-specific standards and guidelines (subject to applicable laws) where TSC are proposed or exist."

See response to PLR-1 and TUS-2 regarding NFMA compliance.

COMMENT

TUS-6: Removal of the Transportation and Utility System LUD in the action alternatives violates the 2012 Planning Rule and requirements of the National Environmental Policy Act (NEPA) because specific geographic management areas were removed from the Forest Plan. Removal of the LUD does not fulfill the stated purpose of the proposed plan amendments, and removal was not disclosed as a secondary purpose for the plan amendment. These geographic corridors connecting the communities located within the boundaries of the Tongass National Forest are intended to be developed and operated as transportation and utility systems in accordance with the State of Alaska's Southeast Alaska Transportation Plan (SATP). Neither the published notice of intent nor the DEIS purpose and need statement disclose the intent to eliminate the TUS LUD. The NEPA requires the significant federal action be disclosed and fully analyzed prior to implementation.

RESPONSE

See responses to P&N-2, TUS-2 and TUS-3. See response to PLR-1 and TUS-2 regarding NFMA compliance.

COMMENT

TUS-7: The Forest Service's conclusion in the DEIS, that there is considerable uncertainty about the future development of Southeast Alaska's road system, is unsupported. This conclusion was used to create transportation systems corridor objective O-TSC-01 in Chapter 5 of the Proposed Forest Plan. Development and delivery of transportation projects in the established transportation and utility corridors is accomplished, in part, by the stability and predictability of the geographically designated Transportation and Utility System (TUS) LUD. This objective (O-TSC-01) is extremely limited and contradictory to the many upcoming and reasonably foreseeable highway projects. With nearly 200 miles of state highway construction recently completed and planned for the near future - and congressionally granted easements underlying hundreds of miles of the TUS LUD - this objective does not reflect the planned development in the TUS LUD.

RESPONSE

The Southeast Alaska Transportation Plan (SATP) states the following on page 2:

> "Alaska may see a decrease in funding in the future. The federal highway trust fund is no longer sufficient to cover surface transportation needs and must be supplemented by the federal general fund, or restructured. State funding which pays for all operating and some capital expenses is expected to decrease as state revenues decline, primarily due to oil

> production declines and price fluctuations. Consequently, the Department must plan for the possibility of reduced financial resources. The SATP recommendations need to account for this year to year uncertainty and plan for periods of reduced funding." (ADOT&PF 2014)

The recent work completed on the roads that were improved through Western Federal Lands funding were relocation and reconstruction of existing roads on Prince of Wales Island. Easements have been given for some sections of the roads on Prince of Wales Island as well as on some roads on other islands to the State of Alaska. These road sections are included in the roads illustrated on Map 21 Prince of Wales Corridors from the Southeast Alaska Transportation Plan, an approved component of the Alaska Statewide Transportation Plan, August 14, 2004. Many of the sections of road illustrated on this map have not been constructed and some sections will not be constructed but were alternative roads. Several maps are included in the Southeast Transportation Plan show roads that will be difficult to construct and expensive to construct considering the terrain, landslides, cultural resources, aquatic resources, stream crossings as well as ferry transportation required to connect some waterways.

Updates to the potential routes and forecasted costs are included in the Southeast Alaska Transportation Plan 2014 Draft. The Forest Plan present and reasonably foreseeable actions and projects (DEIS Appendix C) were developed to be consistent with the Southeast Transportation Plan that provides set of proposed road and utility corridors the State of Alaska is pursuing to meet future transportation and energy needs of Southeast Alaska. The Forest Plan objectives are written to be "…concise, measurable, and time-specific…based on reasonably foreseeable budgets." (FSH 1909.12 Ch. 20, sec. 22.12). Objective O-TSC-01 was written to be achievable and realistic given the fiscal and time constraints as well as anticipated litigation.

COMMENT

TUS-8: The Forest Plan direction for renewable energy and transportation systems corridors direction in Chapter 5 may prove workable for the Forest Service, but the Section 4407 easements and the SATP corridors in the existing TUS LUD must be recognized in the Forest Plan for the multiple-agency and multiple-year planning required to connect the communities of Southeast Alaska. It is unclear how removing the Transportation and Utility System (TUS) LUD will better facilitate the availability of NFS land for the development of existing and future transportation systems, since the State currently holds easements over the vast majority of the TUS LUD. Removal of the of the TUS LUD will likely have the effect of making NFS land less available, create future use conflicts, and deter development of existing and future transportation systems. The depiction of the corridors on the TUS LUD maps in the 2008 plan was informative and consistent with the management direction in the plan concerning the priority of TUS development in those corridors. The State, regulatory agencies, and the public require the disclosure and predictable management of the transportation and utility corridors in the TUS LUD.

RESPONSE

Chapter 3 of the DEIS Transportation section (pages 3-271 to 3-273) included a discussion about the Final Southeast Alaska Transportation Plan (SATP), and described the intent of the road construction to provide access to NFS lands. Pages 3-274 and 3-275 of the DEIS provided a discussion about the TUS LUD under the 2008 Forest Plan. On p. 3-277 of the DEIS in the Transportation environmental consequences section, the Forest Service disclosed that under the action alternatives:

> "Under Alternatives 2, 3, 4, and 5, the existing TUS LUD would be removed from the Forest Plan. Proposed new plan components for Transportation Systems Corridors (TSC) would replace the direction currently found in the Transportation and Utility System LUD. TSC plan components apply only to major road systems such as state and federal highways, railroads, and those identified by the State of Alaska in the current version of the SATP and applicable laws (for example, Section 4407 of Public Law 109-59, Title XI of the Alaska National Interest Lands Conservation Act, Public Law 96-487)."

The Proposed Forest Plan LUD map for Alternative 1 included the TUS LUD, while the LUD map representing Alternatives 2-5 did not include the Section 4407 of Public Law 109-59 easements and the

SATP corridors. FEIS maps have been corrected to include the Section 4407 easements and the SATP corridors.

The management prescription goal in the 2008 Transportation and Utility Systems LUD, and the purpose of the plan direction for transportation systems corridors in Chapter 5 is to facilitate the availability of National Forest System land for the development of major roads; existing and future transportation systems such as those identified by the State of Alaska in the current version of the SATP and applicable laws. (See page 5-13 of the Proposed Forest Plan Chapter 5 for this description.) The transportation systems corridors direction in Chapter 5, including Forest-wide plan components DC-02, DC-03 and DC-04, was written with this purpose in mind.

COMMENT

TUS-9: There is no management advantage by replacing TUS LUD with transportation systems corridors direction in Chapter 5. Without the TUS LUD, the specific property and development rights granted by Congress are not recognized. The TUS LUD provides predictability and transparency, and minimizes potential conflicts with underlying LUD goals and associated management prescriptions should transportation development occur. The TUS LUD represents "a 'window' through the underlying LUD through which roads and/or utilities can be built. To provide the predictability and transparency necessary for the continued development of the infrastructure connecting the communities of Southeast Alaska, the Forest Service should preserve the TUS LUD.

RESPONSE

The Proposed Forest Plan transportation systems corridors direction in Chapter 5 was developed to replace the TUS LUD direction. The TUS LUD direction in the 2008 Forest Plan took precedence over underlying LUDs regardless of whether the underlying LUD was a TUS "Avoidance LUD." Similarly, the applicable transportation systems corridors direction in Chapter 5 takes precedence over other forest-wide and LUD-specific standards and guidelines where transportation systems corridors exist or are proposed. The Introduction to Chapter 3 of the Proposed Forest Plan explained how the plan direction for transportation systems corridors in Chapter 5 is applied to the LUDs and is represented in the table that cross-references the applicable direction that applies to the LUD.

The Proposed Forest Plan LUD map for Alternative 1 included the TUS LUD, while the LUD map representing Alternatives 2-5 did not include the Section 4407 of Public Law 109-59 easements and the SATP corridors. FEIS maps have been corrected to include the Section 4407 easements and the SATP corridors.

The management prescription goal in the 2008 Transportation and Utility Systems LUD, and the purpose of the plan direction for transportation systems corridors in Chapter 5 is to facilitate the availability of National Forest System land for the development of major roads; existing and future transportation systems such as those identified by the State of Alaska in the current version of the SATP and applicable laws. (See page 5-13 of the Proposed Forest Plan Chapter 5 for this description.) The transportation systems corridors direction in Chapter 5, including Forest-wide plan components DC-02, DC-03 and DC-04, was written with this purpose in mind.

See response to TUS-8. Regarding the removal of the Transportation and Utility Systems LUD and adding new direction, see responses to P&N-2, PLR-1, and TUS-2.

COMMENT

TUS-10. The practice of road decommissioning is expensive, wasteful, unnecessary, and reduces ancillary community benefits. Roads support tourism by providing access for a wide variety of activities, including hunting, fishing, hiking, birding, wildlife viewing, photography, recreational vehicle use, boating/kayaking, and more.

RESPONSE

Future transportation needs are considered using the travel analysis process. See Forest Service Travel Planning Handbook FSM 7709.55. Some travel management issues (such as response to visitor demand, open road density, and other wildlife issues) should be considered at a broad scale, while other issues (such as potential conflicts among uses on a particular trail and mitigation measures for a particular stream crossing) are best evaluated at a reduced scale. Travel analysis is often the point where broad-scale issues can be identified. Site-specific issues are addressed at the project level.

Renewable Energy (REN)

COMMENT

REN-1: The Forest Service is commended for emphasizing renewable energy in the Proposed Forest Plan, but encouraging renewable energy at the expense of essential environmental protections takes this policy too far. The Forest Service has not explained why it is necessary to locate renewable energy sites in what are currently "avoidance" areas, particularly in highly sensitive areas like beach and estuary fringe. The Proposed Forest Plan removes the "avoidance" area language that constrained hydroelectric projects in certain areas of the Forest unless an alternative location was not feasible. The renewable energy direction in Chapter 5 of the Proposed Forest Plan now has priority over other plan direction and overrides legally required environmental protection measures. The Proposed Forest Plan is inconsistent in describing the priority of direction that will apply, saying both that "[c]onsistent with the 2008 Forest Plan, renewable energy projects need to be consistent with the standards and guidelines for the respective LUDs affected by energy development" and that "should there be a conflict in direction, the proposed plan components in Chapter 5 would take priority over forest-wide and LUD-specific standards and guidelines (subject to applicable laws)." Neither the DEIS nor Proposed Forest Plan justifies the priority of direction with respect to renewable energy.

RESPONSE

Protection of forest resources is a priority when considering renewable energy development on National Forest System (NFS) lands. The Notice of Intent (NOI) that was published on May 27, 2014 in the Federal Register (79 FR 30074) stated under the "Purpose and Need for Action" that [the Forest Service] will also evaluate other changes suggested in the 5-year review." Concerns were consistently expressed during the Five-Year Review of the 2008 Forest Plan regarding the impact of high fossil fuel prices; the adverse effect of high energy costs on economic diversification and sustainable economic development; and increasing climate change on the quality of life in Southeast Alaska. Concerns were also expressed that the 2008 Plan's direction regarding transportation and utility systems, including the Transportation and Utility System (TUS) overlay Land Use Designation (LUD), were overly complex, confusing, and difficult to implement, creating an impediment to development of hydropower, other types of renewable energy, and transmission lines needed to connect communities to sources of electric power. Based on this review, the responsible official determined to propose changes to the Forest Plan to make the development of renewable energy resources more permissible -- including allowing greater project-level consideration of transportation and utility corridors and removing the TUS overlay LUD -- to stimulate renewable energy development in Southeast Alaska communities, provide low-carbon energy alternatives, and reduce the use of fossil fuels. The "window" and "avoidance" direction in the LUD management prescriptions was also removed because it was associated with application of the TUS LUD which was removed in the Proposed Forest Plan.

Chapter 5 of the Forest Plan includes renewable energy direction that was developed to replace the renewable energy direction in the TUS LUD. Like the TUS LUD direction in the 2008 Forest Plan, the renewable energy direction in Chapter 5 gets applied to a specific geographic location on the Forest (LUD). For example, guideline G-RE-FAC-01 and G-RE-FAC-02 in Chapter 5 of the Forest Plan include the following direction:

G-RE-FAC-01: Utility lines should follow existing or planned transportation systems corridors, including those identified in the Logging Systems and Transportation Analysis (LSTA) and Public Law 109-59.

G-RE-FAC-02: An alternative route can be considered if it reduces or minimizes resource impacts.

Each LUD in Chapter 3 of the Forest Plan provides a table indicating the renewable energy plan components that apply.

Not all NFS lands may be suitable for renewable energy. Chapter 5 includes the following suitability of lands plan component to identify the suitability of renewable energy in a particular area at the project level with site-specific analysis:

SUIT-RE-01: All NFS lands may be suitable for renewable energy sites on a case-by-case basis in consideration of the LUD, ecological and social values, and benefit to Southeast Alaska communities.

The interdisciplinary team (IDT) assigned to a renewable energy project will determine if the proposed renewable energy development is suitable based on the factors in SUIT-RE-01. The management approach for renewable energy further clarifies the intent of SUIT-RE-01 that "Identifying renewable energy sites as suitable is not a commitment but only an indication that the use might be appropriate."

Identifying suitability will help determine if future renewable energy projects and activities are consistent with the following desired conditions:

DC-RE-01: Renewable energy resources (subject to applicable law) contribute to the economic well-being of Southeast Alaska communities.

DC-RE-02: Renewable energy resources are developed in a manner that would maintain and protect National Forest System (NFS) lands and resources.

Protection of resources remains a priority and consistency with the Forest Plan and monitoring of results will continue. The Forest Service developed the set of plan components including the suitability of lands to integrate social, economic, cultural, and ecological considerations. When developing future renewable energy projects, the project or activity must be designed to be consistent with the applicable plan direction in Chapter 5. (Consult Chapter 6 of the Forest Plan regarding Project Consistency Requirements.)

The Proposed Forest Plan is not changing the process the Agency will go through when a proponent desires to develop a renewable energy project. The Forest Service will continue land administration activities under the direction in Chapters 2, 3 and 4. The Chapter 5 plan components take precedence only in the event of conflicting direction. The Forest Service Handbook (FSH) 1909.12, Chapter 20, Section 22.2 guides that if a plan has direction that overlaps, the plan must clearly explain which direction has priority. The Forest Service explained in the Proposed Forest Plan which direction has priority. (See Priority of Direction section in Chapter 1 on p. 1-4, Introduction section in Chapter 5 on p. 5-1, and in the introduction to Renewable Energy Direction section on p. 5-12.)

A Management Approach was added to the Forest Plan in Chapter 5 that reads as follows:

"The addition of the renewable energy plan components do not change the need to ensure that resource protection measures are incorporated throughout project-level planning, construction, and operation of renewable energy sites."

The following sentence was added to Forest Plan, Chapter 1, Priority of Direction:

"Chapter 5 assumes all laws, regulations, and policy pertaining to management of National Forest resources will be followed. Ground-disturbing projects will use the approved best management practices (BMPs) (National Core BMP Technical Guide FS-990a and Alaska Region Soil and Water Conservation Handbook, FSH 2509.22) to avoid, minimize, or mitigate environmental impacts."

COMMENT

REN-2: The Forest Service is right to encourage most kinds of renewable energy, but the definition of "renewable energy" in the Proposed Forest Plan is too broad because it extends to all renewable energy technologies regardless of their environmental effects. For example, poorly designed and located hydropower projects can adversely affect salmon, which are critical to the Southeast Alaskan way of life. The Forest Service should adopt a definition that focuses on beneficial technologies. The current definition does not differentiate between energy resources whose use will force climate change, such as biomass, and those whose use is essentially climate-neutral or even climate beneficial, such as wave action. The current definition does not exclude resources that replenish too slowly to matter for purposes of human civilization. Based on the current definition, old-growth forests that may take hundreds or thousands of years to replenish, but can ever truly be replenished, are classified as "renewable energy."

RESPONSE

The definition of renewable energy in the Proposed Forest Plan is consistent with the Forest Service Strategic Energy Framework, approved by the Chief in January, 2011. Environmental consequences associated with the utilization of various renewable energies are disclosed in a project-level environmental analysis (the reviewer's example of the potential for hydropower to adversely impact aquatic resources is one), but those do not change the fundamental definition of renewable energy. It is not the role of this plan to redefine a commonly agreed-upon term. The Forest believes it is appropriate to maintain the definition in the Forest Plan.

COMMENT

REN-3: If "renewable energy" was defined to focus on beneficial technologies, it would not include biomass. Biomass technology's effect on climate change, its potential demands on forest resources, its harmful emissions, and the fact that Tongass biofuels are not competitive in the market, makes it a mistake for the Forest Service encourage this as a type of renewable energy. The DEIS mentions a Forest Service goal of converting 30 percent of fuel oil heating to biomass. This goal does not exist as a plan component in the Proposed Forest Plan. To avoid confusion, the Forest Service should remove references to this goal from the FEIS for the reasons stated. The Forest Service has not considered the environmental effects of promoting biomass energy as NEPA requires. The Forest Service has not considered these issues, despite the fact that they are integral to understanding the environmental effects of the Proposed Forest Plan's new renewable energy direction. The Forest Service must consider all of these issues before it adopts forest plan components that promote biomass energy, such as those in the Proposed Forest Plan.

RESPONSE

A programmatic analysis of the Proposed Forest Plan's new renewable energy direction was provided on pages 3-289 to 3-290 in the DEIS. As stated on page 3-289 of the Renewable Energy section in Chapter 3 of the DEIS, the new renewable energy direction in Chapter 5 of the Proposed Forest Plan could affect other resources, and these effects are discussed in each respective resource section in the FEIS. The Forest Plan does not specifically authorize biomass projects. Rather, the Forest Plan provides overall strategic direction for management of the Tongass and encourages development of renewable energy without compelling specified Agency actions or guaranteeing specific results. Timber sales can currently support biomass energy products under the 2008 Plan. Several examples of current biomass projects were provided in the DEIS on page 3-286, and the Forest Service acknowledged that "successfully launched projects provide useful learning opportunities as case studies, but future projects will need to continue analyze overall cost savings based on choosing the right technology for the local biomass fuel supply (USDA Forest Service 2015k)."

The Forest Service's "goal to support a transition of 30 percent of the heating oil use in Southeast Alaska to biomass over the next decade (Deering 2014)" as stated in the DEIS on page 3-459, was used by the U.S. Forest Service, Pacific Northwest (PNW) Research Station in a baseline model that was used to construct three management scenarios representing alternative futures for timber harvest in southeast Alaska (Daniels et al., 2016). The Forest Plan includes the following forest-wide goal in Chapter 5:

G-RE-01: The Forest would proactively contribute to sustainable production of renewable energy and energy transmission and distribution across the Forest, on all lands and LUDs, after consideration of other resources and community benefits.

The Forest Service's role does not include performing human health risk assessments of the deployment and usage of materials derived from the National Forests. That role is appropriately held by regulatory agencies such as the EPA and ADEC. As such the Forest Service is not in a position to quantify the extent of "substantial risk to human health."

Site-specific locations and mitigation measures for proposed renewable energy projects would be determined by project-level planning and environmental analysis at the time a specific project is proposed. Issues related to these proposed projects would be disclosed at that time.

See response to REN-1 regarding application of new renewable energy direction in Chapter 5.

COMMENT

REN-4: There is support for providing Southeast Alaskans with clean, affordable and reliable energy, particularly in small communities like Kake, which depend on isolated electric systems that run on high cost diesel. Development of community-based renewable energy solutions is the most effective approach. The Forest Service should invest agency resources to help small, diesel-dependent communities transition to renewable energy. Examples include partnering with these communities to assist with public meetings, consensus building, site surveys, feasibility determination and project selection, and providing advice and resources to help these communities identify and implement energy efficiency and demand side management measures. Projects 5 MW or less, with minimal environmental impacts may qualify for a FERC exemption from licensing.

RESPONSE

Since 2010, USDA agencies, led by the Forest Service and Rural Development, have been directed to develop a strategy known as the Transition Framework to help Southeast Alaska communities transition to a more diversified economy. Renewable energy, forest restoration, young-growth management, and tourism are a few of the components of the transition strategy. This is discussed in Chapter 1 of the FEIS.

The Forest Plan plays a role in supporting the Transition Framework to help move Southeast Alaska communities to a more diversified economy and provides desired conditions/objectives to benefit communities powered by diesel. See response to REN-1 regarding application of new renewable energy direction in Chapter 5 of the Forest Plan.

COMMENT

REN-5: Sensitive habitats should be avoided when renewable energy facilities or transportation and utility corridors are proposed, studied, and ultimately developed. The Proposed Forest Plan's plan components should require siting roads and other infrastructure outside of OGRs, beach fringe, designated wildlife corridors, and other sensitive areas unless an analysis demonstrates that there are no practical alternatives. The action alternatives evaluated in the DEIS do not appear to require this analysis, which leads to the presumption that construction of roads and renewable energy facilities are allowed wherever they may be proposed, irrespective of habitat values. This proposed approach could undermine the integrity of the Conservation Strategy, which was designed to protect important habitat in specific locations from human impacts.

RESPONSE

The Forest Plan does not specifically authorize renewable energy projects. Rather, the Forest Plan provides overall strategic direction for management of the Tongass and encourages development of renewable energy without compelling specified Agency actions or guaranteeing specific results. The analysis presented in the Forest Plan FEIS is programmatic. Project level analyses are conducted for site-specific projects, such as renewable energy sites. Project level analyses quantify all the impacts—beneficial and adverse—of a proposed project. Potential impacts may include impacts to wildlife, wetlands, particular sectors of the economy, and other resources or uses.

Analysis conducted under the NEPA process would evaluate site-specific resource impacts and cumulative effects from renewable energy site development, and adjustments could be made as needed to ensure protection of these resources.

Renewable Energy desired condition DC-RE-02 in Chapter 5 of the Forest Plan requires that the Forest Service develop renewable energy resources "…in a manner that would maintain and protect National Forest System (NFS) lands and resources."

Protection of resources remains a priority and consistency with the Forest Plan and monitoring of results will continue. The Forest Service developed the set of plan components including the suitability of lands (SUIT-RE-01) to integrate social, economic, cultural, and ecological considerations. When developing future renewable energy projects, the project or activity must be designed to be consistent with the applicable plan direction in Chapter 5. (Consult Chapter 6 of the Forest Plan regarding Project Consistency Requirements.) See response to REN-1 regarding application of new renewable energy direction in Chapter 5.

COMMENT

REN-6: Proposed Renewable Energy direction is moving in the right direction, but lacks clear, enforceable direction necessary to promote renewable energy development. Suggested changes to Chapter 5 include:

- **Change wording in the introduction so that "preliminary stage" is not confused with the industry term "preliminary permit."**
- **Adding clear guidance to SUIT-RE-01 about how consideration to LUD, ecological and social values, and benefits to Southeast Alaska communities will be applied.**
- **Change O-RE-01(1) to include all communities in Southeast Alaska.**
- **Change wording in O-RE-01(2) to make it clear that "renewable energy capacity" is intended to be broadly interpreted to include increases in capacity, efficiency, and storage in support of Priority 1.**
- **Add a Management Approach to Facilities (FAC) to acknowledge that some renewable energy facilities may not have previously defined corridors. This is especially true for renewable sites not contemplated when corridors were originally established (e.g., wind, tidal, biomass).**
- **Change G-RE-FAC-01 to acknowledge that existing and planned transportation system corridors should be used when present.**
- **Change G-RE-FAC-02 to acknowledge that viable and beneficial alternative routes outside of established corridors may not be "linear".**
- **Revise scenery design management approach to not be unreasonable or render a project infeasible.**
- **Modify SUIT-RE-TRAN-01 and S-RE-TRAN-01 to provide clear interpretation on lands pertaining to renewable energy development within an Inventoried Roadless Area.**
- **Specify a thirty (30) day timeline for review and issuance of special use permits for exploratory and study activities.**
- **Specify authorized decision-making authorities for each subsection of the Renewable Energy Direction in such a way that helps streamline renewable energy permitting and development.**
- **Ensuring that renewable energy developers are able to construct roads, including in roadless areas.**

RESPONSE

The majority of the above suggestions have been incorporated into the Forest Plan as appropriate. The Forest Plan provides guidance in how LUDs and other resource values are to be addressed. The word "rural" was maintained primarily due to the fact that most of these communities are those that are currently not interconnected or have established renewable energy capabilities available. Specifying timelines for permitting response is outside the scope of the amendment. Agency policy provides for notification whether a proposal for a special use permit will receive further consideration (FSH 2709.11, chapter 10, section 10.3), and other agencies that may have authority over certain proposed energy projects, such as the Federal Energy Regulatory Commission, will establish timelines as appropriate.

The Forest Service developed the set of plan components including suitability of lands (SUIT-RE-01) to integrate social, economic, cultural, and ecological considerations. When developing future renewable energy projects, the project or activity must be designed to be consistent with the applicable plan components in Chapter 5. (Consult Chapter 6 of the Forest Plan regarding Project Consistency Requirements.)

Road development would be considered based on the siting of the project and the objectives of the LUD it is located in, in consideration of all applicable plan components.

COMMENT

REN-7: The renewable energy direction in the Proposed Forest Plan is vague, unenforceable, subject to broad interpretation, and fails to deliver the type of clear and consistent approach and understandable criteria that is required by renewable energy developers to undertake renewable energy development activities. The new direction will also require many assumptions and a great deal of discretion, which does not make renewable energy development more permissible. The renewable energy direction in the Proposed Forest Plan is not consistent with national energy policy and national energy security policy. Additionally, Public Law 106 -511 enacted on November 13, 2000 establishing the Southeast Alaska Intertie System is not referenced, explained, or identified. There is no discussion about how these laws could assist in the development of an enforceable renewable energy resource plan that would reduce air emissions, including greenhouse gases, from mining operations. A renewable energy resource plan or LUD should have been included in the Proposed Forest Plan to recognize pre-existing power site classifications and other potential renewable energy resources on the Tongass such as hydropower, geothermal, wind, tidal, or other renewable energy sites.

RESPONSE

The Forest Service is committed to playing a significant and long-term role in resolving challenges to our energy resources, on which our environment and quality of life depend. The Forest Service Strategic Energy Framework, approved by the Chief in January, 2011, sets direction and proactive goals for the Agency to significantly and sustainably contribute toward resolving U.S. energy resource challenges, by fostering sustainable management and use of forest and grassland energy resources. Challenges include the need to balance the social, environmental, and economic variables influencing and influenced by energy supply.

We acknowledge that a renewable energy plan for the Tongass may be valuable; however, this amended forest plan provides overall strategic direction for management of the Tongass and encourages development of renewable energy without compelling specified Agency actions or guaranteeing specific results.

The plan amendment proposed to remove the "avoidance areas" as the initial impediment for locating renewable energy projects. We understand that this alone does not provide certainty to project developers as they weigh the risks and economics of a project. However, whether a specific renewable energy plan exists will not reduce the need for the Forest to balance the social, environmental, and economic variables for those communities within southeast Alaska.

Response to comments related to mining are referenced under MIN-1 through MIN-8.

COMMENT

REN-8: Renewable Energy projects should not be prioritized based on market destination or end-line user as proposed in the renewable energy direction in Chapter 5 of the Proposed Forest Plan. The use of the term "export" to describe sale of renewable energy to markets outside of Alaska is inappropriate. Selling energy across state boundaries, and even across the Canadian border pursuant to North American Free Trade Act, is a well-established and commercially reasonable activity typical of the utility sector. Even if power is not sold locally, renewable energy projects in the Tongass create rural "green jobs," local expenditures, and local tax revenue in southeast Alaska, all of which are meaningful benefits, which the Forest Service should recognize. The Forest Service should ensure timely and adequate staff participation in all renewable energy development proposed on National Forest System lands, in accordance with FERC's permitting and licensing processes, and treat all developers equally without prioritizing projects based their intended market or user.

RESPONSE

The Forest Service acknowledges in the desired conditions of the Renewable Energy Direction that renewable energy projects contribute to the economic well-being of Southeast Alaska communities. To ensure Southeast Alaska has the benefit of sustainable economic development, the plan components provide for a priority consideration of renewable energy projects based on whether the projects lead to a decrease in the number of Southeast Alaska rural communities powered by diesel generators, an increase in energy capacity, efficiency, or storage at existing projects, or an export of renewable energy resources without power benefitting Southeast Alaska communities. This prioritization is consistent with the goals of the Transition Framework and the Secretary's Memorandum, and is reflected in the recommendations of the Tongass Advisory Committee. That group noted that relief to communities is ensured where the Forest Plan provides for increased access to new renewable energy and hydropower resources within the Tongass, thereby allowing communities to enjoy more affordable energy for current purposes and future growth, while also supporting the growth and prosperity of a new young growth manufacturing industry through more affordable renewable energy.

The Forest Service also acknowledges that adequate staff participation in all renewable energy development projects proposed on the Tongass is desirable; however, in the 2011 Forest Service Strategic Energy Framework, the agency identified the need to increase the Agency's institutional capacity with the specialized skills necessary to assess the effects of existing and new technologies that affect America's forests. The Tongass has similar challenges regarding capacity and specialized skills. Applying priority considerations to renewable energy projects also gives the Tongass an opportunity to respond to proposals more effectively given limited agency resources.

COMMENT

REN-9: The Proposed Forest Plan does not make it clearer and easier for roads and utility systems to be built to facilitate less expensive construction of renewable energy projects, or give greater assurance of speedy approval for roads or transmission facilities through roadless areas. These amendments would also aid economic development of mineral deposits in the forest. Transportation and utility access was guaranteed through most of the Tongass National Forest by Title XI of ANILCA, which set up a process guaranteeing access through conservation system units after the agency ruled that IRAs are covered under that definition. Although the existing alternatives propose to provide more "flexibility" on a "case-by-case" basis for roads and utilities, the language does not provide sufficient certainty of approval to encourage developers to advance costly reconnaissance studies of potential projects that could be impacted by 2001 Roadless Rule regulations. In order to prevent needless costs and development uncertainties, the Forest Service should determine how to handle future requests for renewable energy developments in 2001 roadless areas.

RESPONSE

Not all NFS lands may be suitable for renewable energy. Chapter 5 includes the following suitability of lands plan component to identify the suitability of renewable energy in a particular area at the project level with site-specific analysis:

SUIT-RE-01: All NFS lands may be suitable for renewable energy sites on a case-by-case basis in consideration of the LUD, ecological and social values, and benefit to Southeast Alaska communities.

See response to REN-1 regarding application of new renewable energy direction in Chapter 5. The new plan components are set to 'encourage renewable energy production' (Proposed Forest Plan, Page 5-12).

The Forest Service acknowledges that these new components will make it 'easier for roads and utility systems to be built'; 36 CFR 219.13 (a) allows for such LUD changes. See response to TUS-2. There is no authority for the responsible official to modify federal law enacted by Congress or be inconsistent with higher-level direction through forest planning (See Forest Plan Priority of Direction in Chapter 1).

Conservation system units on the Tongass National Forest are statutorily designated areas; roadless areas on the Tongass National Forest are administratively established, designated by the Secretary of Agriculture in accordance with the 2001 Roadless Rule. The Priority of Direction as explained on page 1-4 of the Proposed Forest Plan provides that higher-level direction (federal law and regulations) take precedence over the Forest Plan direction. The clear intent of the Proposed Forest Plan is to encourage renewable energy production within the laws and regulations. Changes to the 2001 Roadless Rule are outside of the scope of this amendment.

COMMENT

REN-10. The Forest Plan should incorporate the September 29, 2006 Memorandum of Understanding (MOU) between U.S. Department of Agriculture, Forest Service, Alaska Region, and the State of Alaska Department of Natural Resources and Alaska Department of Transportation and Public Facilities (FS Agreement No. 06MU-11100100-151; State of Alaska Agreement No. ADL 107516), which specifically identified rights of way for transmission corridors and log transfer facilities illustrated in Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEALU). The Forest Service must also consider the impacts of these reciprocal easements in the EIS.

RESPONSE

The FEIS acknowledges Public Law 109-59, as amended, and the rights-of-way and easements identified in Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEALU) Map 92337 under existing conditions in Chapter 3 under Land Uses, Ownership, and Adjustments and the Transportation sections. The MOU and easements for transportation and utility corridors are described and analyzed in the Transportation section in Chapter 3 of the FEIS.

Renewable energy guideline G-RE-FAC-01 in the proposed Forest Plan has been revised in the Forest Plan to include the easements as follows:

G-RE-FAC-01: Utility lines should follow existing or planned transportation systems corridors, including those identified in the Logging Systems and Transportation Analysis (LSTA) and Public Law 109-59.

Minerals and Mining (MIN)

COMMENT

MIN-1: The proposed TLMP Amendment should discuss the adverse impacts to the mining sector from re-imposition of the Roadless Rule on the Tongass.

RESPONSE

The 1872 Mining Law gives a statutory right of reasonable and necessary access related to the exploration and development of mineral properties, and the 2001 Roadless Area Conservation Rule (Roadless Rule) recognizes this right. This statutory right is subject to reasonable regulation for the protection of surface resources. If the inventoried roadless area is open to mineral entry, locatable mineral mining, including certain activities ancillary to the mining such as access roads for exploration and development, may be approved.

The Roadless Rule anticipates a number of other permissible activities, including exploration and development of leasable minerals, such as oil and gas or geothermal resources, hydropower projects, forest restoration projects, and certain special uses that do not involve road construction or reconstruction. The Forest Service will work with the project proponent to determine the permissible activities during NEPA analysis of a proposed project.

COMMENT

MIN-2: The TLMP Amendment should include mining in the multiple use strategy and include enforceable mechanisms to promote mineral and strategic mineral development, including a Mineral and Strategic Mineral LUD; interpreting "reasonable access" for mining operations within the Tongass to mean road access for mineral and leasable mineral development; including clear guidelines allowing for cutting trees in association with mining exploration and development access on the Tongass; and including an alternative that would allow access to future mineral leases (including geothermal leases) on the Tongass, even if such alternative(s) would require a modification to the Roadless Rule.

RESPONSE

As stated above, the 1872 Mining Law gives a statutory right of reasonable and necessary access related to the exploration and development of mineral properties, and the Roadless Rule recognizes this right. This statutory right is subject to reasonable regulation for the protection of surface resources. If the inventoried roadless area is open to mineral entry, locatable mineral mining, including certain activities ancillary to the mining such as access roads for exploration and development, may be approved. It is important to note that "reasonable access" does not have a strict interpretation, and in many cases road access is not the most reasonable alternative or the most cost efficient. If a mineral exploration or development project is proposed within an inventoried roadless areas, the Forest Service will work with the project proponent to determine the permissible activities, including reasonable access, during NEPA analysis of the proposed project.

Exploration and development of leasable minerals, such as oil and gas or geothermal resources, are not prohibited under the Roadless Rule.

COMMENT

MIN-3: Thirty day turnaround for issuance of Special Use Permits to those holding mining claims.

RESPONSE

Specifying timelines for permitting response is outside the scope of the amendment. There is no regulatory basis to provide mining claimants priority or special treatment when it comes to the processing of Special Use Permits. Agency policy provides for notification whether a proposal for a Special Use Permit will receive further consideration (FSH 2709.11, sec 10.3).

COMMENT

MIN-4: The Forest Service should allow roads through roadless areas to guarantee more affordable access to mineral developments. Any plan update should be modified to guarantee more affordable access to mineral developments.

RESPONSE

The Roadless Rule allows for the construction of roads in IRA's consistent with the level of locatable mineral exploration or development. Reasonable access in some of the more remote locations on the Tongass has frequently been interpreted in the past as helicopter or water access. The Bokan Mountain and Niblack Projects mentioned did not propose road access for their projects, likely due to the costs of construction and maintenance, as well as reclamation bonding for said access relative to the lesser costs of helicopter and boat access. Economics are only one of many variables considered in determining reasonable access.

Project-level decisions, such as access roads to specific mining projects, are beyond the scope of the Forest Plan (and thus the currently proposed amendment).

COMMENT

MIN-5. The impacts to mining from the President's November 3, 2015 Memorandum directing agencies to avoid and minimize harmful effects to natural resources caused by land- or water-disturbing activities, and to ensure that any remaining harmful effects are effectively addressed are impossible for the public to predict and must be disclosed in the EIS.

RESPONSE

Nationally, the Forest Service is developing a brief regulation that establishes clear goals for the use of mitigation on National Forest System lands and a set of directives in the Forest Service Manual and Handbook that clarify methods, tools, and their appropriate use to accomplish this. The regulation and guidance are in development. When draft regulation is developed, it will include an opportunity to provide specific input. When final, it will be provided to the Tongass and be implemented. Currently, the Final Directives are anticipated in late 2017. Additional information is available at: http://www.fs.fed.us/emc/nepa/FSMitigationPolicy.htm

COMMENT

MIN-6. Minerals management activities should be equally facilitated on any and all lands, not just what someone perceives as highest potential areas. See MG1.A (Forest Plan Chapter 3, Minerals).

RESPONSE

Changes to the Minerals overlay LUD standards and guidelines are outside of the focused scope of this Forest Plan amendment. Forest-wide Minerals and Geology Standards and Guidelines are provided in Chapter 4 of the Plan, where MG2.II provides direction to "encourage" exploration, development, and extraction of mineral on all lands open to mineral entry.

COMMENT

MIN-7. Forest Plan Chapter 3, Minerals, TRAN A, should not require reasonable access to mineral resources to be consistent with other resource values.

RESPONSE

Changes to the Minerals overlay LUD standards and guidelines are outside of the focused scope of this Forest Plan amendment. Ensuring other resources are protected during the planning, approval, and operation of roads for mineral exploration and development is consistent with the Mineral LUD goals, objectives, and desired conditions and locatable mineral regulations at 36 CFR 228, Subpart A.

COMMENT

MIN-8. The Forest Plan should acknowledge acceptance of other agency requirements and ability to jointly bond mineral projects.

RESPONSE

Changes to the Minerals overlay LUD standards and guidelines are outside of the focused scope of this Forest Plan amendment. 36 CFR 228.8(h) authorizes the Forest Service to accept certifications and other approvals issued by State or other Federal agencies with similar or parallel requirements. Further, Forest Service Manual 2817.24 provides that "All reasonable effort should be made, through agreements with States which require bonds for reclamation disturbances in National Forests, to avoid double bonding."

Wherever possible the Forest Service works cooperatively with states to avoid duplication or double bonding; however, The Forest Service should not waive its bond requirements in lieu of a state bond involving an instrument that is not acceptable to the Forest Service.

Carbon Storage and Global Warming (CARB)

COMMENT

CARB-1 and CARB-2: The Plan Amendment should better discuss and analyze the critical role of the TNF in global carbon sequestration and storage and the importance to the climate-change mitigation contributions of forests in general, and of the Tongass in particular. In particular the Forest Service should consider a no-harvest scenario as a mitigation measure to prevent a carbon flux deficit from federal forests in southeast Alaska. The FS did not consider the full body of science showing how each alternative will likely result in an increased concentration of CO_2 in the atmosphere in the near and long term.

RESPONSE:

Regarding the scope of the plan amendment, see response to PLR-1.

The suggestion that the Tongass "consider an alternative that would mitigate climate change by lowering CO_2 emissions and maximizing carbon storage" is beyond the scope of the amendment and would not meet the purpose and need of this action. That notice indicated that the purpose of the amendment was: "as needed to accomplish the transition to young growth management over the next 10 to 15 years while retaining the expertise and infrastructure of a viable timber industry in Southeast Alaska, as outlined by the Secretary in Memorandum 1044–009."

The analysis in the Forest Plan has been modified to acknowledge the substantial role the Tongass plays in carbon storage and the importance to climate change mitigation. Additional text has been added in Chapter 3.1 of the Final EIS (pages 3-13, 3-21, 3-23, 3-26). In response, we revised the evaluation of GHG storage and the comparison among alternatives in relative contribution to atmospheric GHG's to clarify the potential differences among alternatives in carbon sequestration and storage (pages 3-13-14). The analysis qualitatively discloses that carbon storage on the Tongass will remain substantial under each alternative (while disclosing the relatively small differences among alternatives). However, based on the scope of this amendment outlined in the 'Notice of Intent To Prepare An Environmental Impact Statement' published on 27 May, 2014, the purpose of the amendment is to: "accomplish the transition to young growth management over the next 10 to 15 years while retaining the expertise and infrastructure of a viable timber industry in Southeast Alaska, as outlined by the Secretary in Memorandum 1044–009." Comments suggests that the Tongass examine the contribution of the Tongass "in general" to climate change mitigation by discussing the role of undisturbed forest. As an amendment, rather than revision, the scope of options being considered does not include the potential for no timber harvest and therefore the consequences of such an alternative are not considered.

The Secretary's memo makes clear that the Department of Agriculture is committed to not only maintaining Southeast Alaska's exceptional natural resources in perpetuity but is equally committed to doing its part to ensure that communities within and adjacent to the Tongass National Forest are economically vibrant. The proposed action for the Amendment is intended to bring these two goals hand in hand. To do so, there will be costs and in the case of carbon storage we acknowledge that in order to bring to fruition the multiple-use objectives of this document as well as the overall mission of the Forest Service, the Tongass will incur a short- and mid-term net loss of total carbon storage through GHG emissions as a result of timber harvest on the Tongass.

COMMENT

CARB-3: The direct and indirect effects conclusion in the DEIS mistakenly describes the estimation of the effects of the Plan Amendment on carbon storage as "complex". There is disagreement with the DEIS' conclusion of no significant effect, claiming this conclusion is arbitrary.

RESPONSE:

Additional discussion and citations regarding the direct and indirect effects of logging under the Amendment have been added to the text in Chapter 3.1 of the Final EIS.

COMMENT

CARB-4: The DEIS was insufficient in identifying a relevant time frame in its climate change analysis and should establish quantifiable criteria for measuring carbon emissions and lost carbon storage according the Revised DRAFT CEQ.

RESPONSE

Additional discussion and citations regarding the differential ability of old-growth forest to sequester carbon dioxide and store carbon as well as a more explicit discussion about relevant timescale have been added to the text in Chapter 3.1 of the Final EIS. The Tongass National Forest currently sequesters large quantities of carbon (referred to it as the combined outcome of carbon "storage" and carbon "emissions"). Timber harvesting and forest management can affect a forest's ability to store carbon as well as emit carbon as carbon dioxide and other greenhouse gasses. The climate change discussion in Chapter 3's Affected Environment provide added discussion of the dynamics of carbon storage and loss due to proposed actions identified in this amendment. In summary, harvesting old growth creates a net release of CO2 into the atmosphere – particularly in short- and mid-term. There is uncertainty regarding long-term CO2 release particularly because of the importance of how the wood is used (durable or nondurable products), the regrowth of young forests, and market dynamics related to substitution.

The revised Chapter 3 also more clearly discloses uncertainty of GHGs contributions in the short- and long-term that result from timber harvest (both old-growth and young-growth) for each action alternative. The EIS does not present a quantitative analysis of carbon emissions, nor is there a requirement to do so (see response to CARB-23). Given the level of uncertainty in parameters related to the net contribution of GHGs, an attempt to quantify the evaluation would not provide clarity but instead result in a false sense of certainty. We qualitatively evaluate differences among the alternatives. The qualitative analysis provides the necessary level of information to evaluate the relative differences in carbon losses and gains for each alternative, thus providing the information for the deciding official on the relative contribution of GHGs from the proposed actions (USDA-Forest Service 2009).

COMMENT

CARB-5 and 6: The Forest Service's assumptions that carbon storage in wood products and thinning can offset emissions are incorrect. Also incorrect is the statement that "thinning activities may lead to a net gain or a net release of carbon…depending on how the thinning is conducted."

RESPONSE

Additional discussion and revisions in text have been added to Chapter 3.1 of the Final EIS regarding the effects of total carbon storage as a result of logging (both old-growth and young-growth forests) for each alternative. Additional discussion and citations regarding likely effects the social costs of carbon emissions as a result of proposed actions for each alternative have been added to the text in Chapter 3 of the Final EIS).

COMMENT

CARB-7, CARB-23 and CARB-24: The Forest Service should adopt the conservation alternative (e.g. no harvest alternative), provided by the Conservation Consortium, to comport with CEQ guidelines, the Paris climate agreement, and efforts to reduce climate damages from CO2 pollution. The FEIS should also include a cost-benefit analysis of avoiding damages to the environment cause by climate change "so as to level the economic playing field" in compliance with Executive Order 12866. A carbon life-cycle analysis should be presented to illustrate the outcome of the alternatives as well as an evaluation of the social cost of carbon emissions based on Executive Order 12866 and using the Interagency Working Group guidelines on carbon costing. (A GEOS Institute Analysis)

RESPONSE

See CARB-23 and CARB-24.

COMMENT

CARB-8: The DEIS arbitrarily and incorrectly characterizes the role of the public lands in southeast Alaska as insignificant by comparing global forest carbon sequestration to carbon storage in marine ecosystems. Further, this approach, which compares global storage in forests to global carbon storage in oceans (and, indeed, the atmosphere itself), fails to provide a cumulative effects analysis at a meaningful scale.

RESPONSE

Additional documentation and evaluation of cumulative effects of climate change have been added to the text in Chapter 3.1 of the Final EIS. See Response to CARB-4 for a fuller discussion of the effects analysis using a more meaningful time scale.

This section is made of 2 parts: 1) the effect of the project Amendment on climate change; and 2) the effects of climate change on the project Amendment. The first part of this section addresses the cumulative effects of GHG emissions and other contributors to climate change; while the second part addresses cumulative effects of the project on carbon sequestration (carbon storage and emissions).

This section highlights the conclusion that higher levels of harvest (e.g., the total available harvest under each of the alternatives) would only occur if additional manufacturing facilities and markets are developed, as well as other factors such as funding and staff levels. In addition, we added a brief discussion that addresses the different time scales these effects could have on carbon sequestration as discussed in Environmental Consequences section). The net contribution to atmospheric CO2 is lower given longer time scales due to regeneration, particularly if wood products include 'storage' products, if biomass substitutes for local fossil fuel use, and if market substitution (also called market leakage) is relatively high (e.g. Jonsson et al. 2012).

The global contribution of carbon storage that the Tongass provides is acknowledged in the Secretary of Agricultures memo to the US Forest Service in providing the scope and need for action to this Plan amendment. We have added language in Chapter 3.1 to further demonstrate our understanding of the forest's global importance in storing carbon. The Secretary's memo makes clear that the Department of Agriculture is committed to not only maintaining Southeast Alaska's exceptional natural resources in perpetuity but is equally committed to doing its part to ensure that communities within and adjacent to the Tongass National Forest are economically vibrant. The proposed action for the Amendment is intended to bring these two goals together. We acknowledge that in order to address the multiple-use objectives of this document we will incur a net loss of total carbon storage through GHG emissions as a result of timber harvest on the Tongass. No timber harvest, would not meet the purpose and need of the amendment and is outside the scope of the document.

COMMENT

CARB-9 and CARB-4: The DEIS's analysis is inaccurate because it ignores the differential ability of old-growth forest to sequester carbon dioxide and store carbon within the timeframe relevant to climate change mitigation. The Forest Service should evaluate timescale in light of scientific literature which suggests that "large-scale changes" in land use must occur within 10 to 15 years.

RESPONSE

Additional discussion and citations regarding the differential ability of old-growth forests to sequester carbon dioxide and store carbon as well as a more explicit discussion about relevant timescale have been added to the text in the Climate and Air section of the Final EIS. The Tongass National Forest currently sequesters large quantities of carbon (referred to as carbon "storage"). Timber harvesting and forest management can affect the timing (e.g., short- term mid-term) and net amount of carbon stored in forests. The climate change discussion in Chapter 3's Climate and Air section provides added discussion of the

dynamics of carbon storage and loss due to proposed actions identified in this amendment. In summary, harvesting old growth creates a net release of CO2 into the atmosphere – particularly in short- and mid-term. There is uncertainty regarding long-term CO2 release particularly because of the importance of the use of the wood, the regrowth of young forests, and market dynamics related to substitution (sometimes called market leakage – e.g. Jonsson et al. 2012).

As discussed in previous responses to comments (see CARB-4) a quantification of carbon flux due to the many pathways created naturally or by management actions proposed in this amendment is unnecessary to make an informed decision regarding the proposed action because a qualitative analysis provides the necessary level of information to evaluate the relative differences in carbon losses and gains for each alternative, thus providing the information for the deciding official on the relative contribution of GHGs from the proposed actions (USDA-Forest Service 2009). However, this amendment proposes to discontinue old-growth timber harvest after 15 years, and as such, we can expect a net decrease in carbon emissions from current levels through time.

COMMENT

CARB-10, CARB-1 and CARB-23: The DEIS's figure for the overall size of the carbon cycle is incorrect and should be corrected in the FEIS. A quantitative evaluation of the emissions savings or losses attributable to the Plan is insufficient, incorrect and misleading.

RESPONSE

We revised the EIS to more clearly describe the potential of the Tongass action and contributions to atmospheric greenhouse gasses. See responses to CARB-1 and 23 for additional details pertaining to these comments.

COMMENT

CARB-11: Forest Service Should Leverage Taxpayer Dollars to Help Local Communities Transition from Old-growth Logging, while also Contributing to Carbon Storage.

RESPONSE

The Tongass National Forest appreciates the support for the intent of the amendment – to help local communities transition from old-growth logging while continuing to contribute to carbon storage. Each of the action alternatives seek to help local communities transition to forest management based largely on harvest of young-growth forest and reduces harvest of old-growth forest over a 15 year transition period. Funding for these actions comes from the Federal budget process through the Department of Agriculture. The intent of this Plan Amendment is to provide opportunities for the development of project-level plans that implement the transition of predominantly old-growth logging to harvest of young-growth forests. An outcome of this transition is the contribution of increase carbon storage from its current condition on the National Forest.

COMMENT

CARB-12: The DEIS did not include all relevant literature in the analysis of carbon and suggest the agency explain how the various alternatives, including the selected alternative, affect the amount of stored carbon on the Tongass.

RESPONSE

We appreciate the additional references mentioned and have considered them in our analysis and conclusions regarding effects of each alternative on climate change. We revised the EIS to more clearly describe the potential of each alternative to contribution to atmospheric greenhouse gasses and the relative amount of stored carbon on the Tongass for each alternative and have cited the literature that supports our findings.

COMMENT

CARB-13: The FEIS should provide more detail, including stronger literature citations, regarding the recognition that rising temperature accelerates decomposition particularly in instances of old-growth logging and regarding changes in decomposition rates.

RESPONSE

We revised the evaluation of GHG storage and the comparison among alternatives in relative contribution to atmospheric GHG's. As noted in our analysis we emphasize the dynamics of soil organic matter decomposition are complicated due to the many different factors involved in the process and cite the most recent study that identifies a lack of consensus in the science community on the temperature sensitivity of soil carbon decomposition to changes in regional temperature (Davidson and Janssens 2006). Many factors, including the relative mix of soil organic matter along a continuum of decomposability, and an array of environmental constraints (abiotic and biotic conditions) obscure the intrinsic temperature sensitivity of soil organics to decomposition (Davidson and Janssens 2006) suggesting a clear evaluation of the outcome of warming climate on decomposition on the Tongass is not feasible. Depending on environmental features such as changes in soil moisture, changes in water table, changes in predominance of decomposition-resistant soil carbon, the rate of soil carbon movement into streams, lakes, and marine environments, and other factors outlined in the most comprehensive recent review by Davidson and Janssen (2006), the net direction (increase or decrease) in GHG contribution to the atmosphere as a result of decomposition of soil carbon is uncertain. However, the ultimate response is one of increased decomposition with increasing temperature (D'Amore, pers. comm. 2016).

COMMENT

CARB-14: The DEIS does not adequately describe the difference in resilience to climate change between old-growth and young forests. The FEIS should evaluate how each alternative will vary in its preservation of old-growth and how that may have bearing on overall forest resilience for future net carbon flux.

RESPONSE

We appreciate the input suggesting improvements in evaluation of the relative value of old-growth vs. young-growth forest for carbon storage particularly in light of the general understanding that old-growth (or primary forest) may be more resilient to climate change. In response, we revised the evaluation of GHG storage and the comparison among alternatives in relative contribution to atmospheric GHG's. We note however, that our analysis discloses that evaluation of the relative stability of biomes and the climate niche of dominant tree species on neighboring Chugach National Forest suggests that the temperate coastal rainforest of Alaska is particularly resilient to expected changes in climate in the region over the next 30 to 50 years (see Hayward et al. n.d.[5]: Chapter 6). Consequently, there is no direct evidence to suggest that that regenerating rainforest on the Tongass will be less resilient and therefore, that it will have reduced capacity for carbon storage under future climate conditions than it displays currently.

COMMENT

CARB-15: Rain and gale force winds are expected to increase in Southeast Alaska due to changes in climate. As such the agency should adopt mitigation policies, including standards and guidelines, in anticipation of rising winds and rain during this Plan Amendment related to soil and slope suitability, riparian area (RAW buffers) and other buffers around sensitive and important areas such as beach fringe.

RESPONSE

The current minimum size requirement for beach buffers (1,000 foot width from shoreline) and riparian management buffers (minimum of 100 feet on either side of Class I and II streams), will continue to be

[5] G. D. Hayward, S. Colt, M. McTeague, T. Hollingsworth. eds. (n.d.). Climate change vulnerability assessment for the Chugach National Forest and the Kenai Peninsula. Manuscript in preparation.

implemented for the 2016 amendment. While some young-growth timber harvest is proposed within these buffers under alternatives 2, 3, 4 and 5, the new standards identified in the amendment allow for only partial harvest of these areas (e.g. maximum size of 10 acres and up to 35% removal of the stand) and in the case of Alternative 2, not to exceed the 15 year transition. Furthermore, the forest plan standards and guidelines for Reasonable Assurance of Windfirmness (RAW) buffers and steep slopes are flexible in that the application of RAW buffers and soil conservation measures depends on the specific conditions encountered at each site. This flexibility allows the application of the RAW buffers and steep slope soil conservation practices to be tailored to site specific conditions and anticipated increases in precipitation resulting from a changing climate. The anticipated changes in climate may require a more conservative approach in areas already at risk for windthrow or loss of slope stability. The FEIS Climate and Air section of Chapter 3 discusses the risks and effects associated with anticipated climate change on the forest.

Monitoring of windthrow within stream buffers is ongoing on the forest and data from that monitoring is considered when designing projects and determining the need for, or design of RAW buffers. This monitoring began on the Tongass in 2000 and has continued yearly, for a total of 15 years of monitoring results (see annual Forest Plan Monitoring and Evaluation Reports at http://www.fs.usda.gov/main/tongass/landmanagement/planning). The proposed management within buffers under the amendment (size openings and percent harvest) have not yet been implemented, nor undergone monitoring to provide the Forest Service information on the effectiveness of the overall buffers when managed in this way. Through future monitoring the Tongass will evaluate effectiveness. Until new information is available the Tongass will use the standards, guidelines and management approaches identified in 2016.

COMMENT

CARB-16: The Forest Service should undertake a climate change resiliency assessment across the Tongass and an analysis to discover which watersheds will be most resilient to future climatic change. Additionally, the agency should invest in research to understand how climate change will affect stream flows, stream temperatures, and salmon populations/spawning success/ fish production.

RESPONSE

The Forest Service appreciates the suggestion to assess the climate change resiliency of the Tongass. The Tongass National Forest, in line with national policy has been collaborating with partners since 2012 improving understanding of the potential consequences of climate change for ecosystems and resources in southeast Alaska. The recently published assessment (EcoAdapt 2014[6]) is an example of this effort. Similarly, the USFS was the lead agency, collaborating with a wide array of partners, for a recent workshop examining water resources and anadromous fisheries in response to climate change [Climate Change in Southeast Alaska – Informing Sustainable Management of Water Resources and Anadromous Fisheries. April 12-15, 2016]. These accomplishments demonstrate that the Tongass recognizes the value of climate assessments and is actively incorporating climate science into its work. These efforts specifically focused on salmon and their fisheries. Regarding the suggestion that the Tongass "invest in research to understand how climate change will affect stream flows, stream temperatures, and salmon populations/spawning success/ fish production." Based on law and policy the National Forest System does not conduct research (cite law/policy) but is involved in cooperative and, administrative studies modeling hydrologic changes and consequences for salmon as well as several other climate change research studies in progress with the Forest Science Laboratory of the Pacific Northwest (PNW) Research Station.

COMMENT

CARB-17: Cited literature related to climate change in the Plan Amendment contains "hypothetical as well as irrelevant" information. The Plan Amendment's purpose and need to transitioning from and old-growth dominated harvest strategy to harvesting young growth trees is premature.

[6] EcoAdapt. 2014. A Climate change vulnerability assessment for aquatic resources in the Tongass National Forest. EcoAdapt, Bainbridge Island,WA

Furthermore, the amount of timber proposed for harvest over the transition period and its effects on total carbon storage is inconsequential at a global scale. The Amendment should clarify the carbon flux discussion, including the ultimate destiny of carbon storage and emissions after harvest.

RESPONSE

Best available science (e.g., IPCC 2014, Melillo et al. 2014, Millennium Ecosystem Assessment. 2005[7]) and broad science consensus indicates that the preponderance of evidence supports the contention that climate change is occurring and that human production of greenhouse gases is a major contributor. National policy as indicated by the 2012 Planning Rule (36 CFR 219) directs the Forest Service to disclose the consequences of its actions in relation to climate change. Regarding the relationship of forest condition on the Tongass and carbon storage, analysis of field data (Barrett et al. 2014) provides evidence regarding the status of carbon storage on the Tongass. The agency agrees that carbon in wood products is stored for variable periods of time, and potentially for long periods in structural lumber and other durable products (http://www.fs.fed.us/ecosystemservices/carbon.shtml). Revisions made in Chapter 3 of the FEIS (Climate and Air section) further clarify the status of carbon storage on the Tongass, to the extent that can be resolved with current scientific understanding.

COMMENT

CARB-18: The agency should improve the FEIS' discussion related to increased carbon emissions which would occur with additional biomass fuel development, including disclosure of the environmental effects caused by biomass fuel combustion for air quality and human health. Further, a more specific discussion should be added to the FEIS related to substituting biomass fuels for fossil fuels and compare these two energy systems in terms of total CO_2 emissions. Finally, the Amendment should prepare a "no- harvest" alternative to evaluate a more ambitious climate change mitigation strategy.

RESPONSE

This comment is outside the scope of this amendment. The Forest Service's role does not include performing human health risk assessments of the deployment and usage of materials derived from the National Forests. That role is appropriately held by regulatory agencies such as the EPA and ADEC. As such, the Agency is not in a position to quantify the extent of "substantial risk to human health".

Further the Forest isn't distinguishing between renewable energies, of which biomass is one type, nor is it authorizing specifically biomass. However, timber sales can and are currently being used to support biomass energy products. The Forest believes it is appropriate to maintain the goal as stated in the EIS; no change made. Also, see response to CARB-1 and CARB-2 for more discussion the "no harvest" alternative to mitigate for climate change.

COMMENT

CARB-19: The agency should remove biomass from its list of renewable energies and add more content about wood biomass combustion and the carbon cycle. More discussion on the effects of carbon emissions as a result of biomass fuel development on air quality should be included in the FEIS.

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[7] IPCC. 2014. Summary for policymakers. In: Field, C.B.; Barros, V.R.; Dokken, D.J.; Mach, K.J.; Mastrandrea, M.D.; Bilir, T.E.; Chatterjee, M.; Ebi, K.L.; Estrada, Y.O.; Genova, R.C.; Girma, B.; Kissel, E.S.; Levy, A.N.; MacCracken, S.; Mastrandrea; P.R.; White, L.L. eds. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA: 1-32.

Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 841 p.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

RESPONSE

This is outside the scope of this amendment. The Forest Service's role does not include determining what type of renewable energy (e.g., zero-emitting vs. "dirty" energies) or performing human health risk assessments of the deployment and usage of materials derived from the National Forests. That role is appropriately held by regulatory agencies such as the EPA and ADEC. The Forest is not authorizing specifically biomass; however, sales can and are currently used to support biomass energy products. The Forest believes it is appropriate to maintain the goal as stated in the EIS and reiterates that it is not distinguishing between renewable energies. If the Forest were to begin to see numerous proposals for biomass utilization at a large scale, additional NEPA would then account for this.

Please refer to AIR-1 response for more information on the effects of increase carbon emissions on air quality.

COMMENT

CARB-20: DEIS failed to analyze lost opportunities for zero-emitting renewable energies caused by biomass facility subsidies.

RESPONSE

The amendment does not explicitly favor one form of renewable energy over another, nor is it focused on biomass. As the commenter notes, there have been a number of conversion to biomass fuel projects. The Forest is not authorizing specifically biomass; however, sales can and are currently used to support biomass energy products. The Forest believes it is appropriate to maintain the goal as stated in the EIS and reiterates that it is not distinguishing between renewable energies. The EIS clearly states that successfully launched conversion projects provide useful learning opportunities as case studies, but future projects will need to continue to analyze the cost/benefit savings based on choosing the right technology for the local biomass fuel supply. Each project will need to weigh the cost of converting to biomass with the cost of other readily available energy sources.

Please refer to AIR-1 response for more information on the effects of increase carbon emissions on air quality and GHGs.

COMMENT

CARB-021 and CARB-8: The Forest Service failed to adequately consider the cumulative effects of programmatic alternatives and climate change, as recommended by various climate change experts, also supported in agency documents, such as the Alaska Region's Climate Change Assessment (2010).

RESPONSE

Additional documentation and evaluation of cumulative effects of climate change have been added to the text in Chapter 3.1 of the Final EIS.

This section is made of 2 parts: 1) the effect of the project Amendment on climate change; and 2) the effects of climate change on the project Amendment. The first part of this section addresses the cumulative effects of GHG emissions and other contributors to climate change; while the second part addresses cumulative effects of the project on carbon sequestration (carbon storage and emissions).

This section highlights the conclusion that higher levels of harvest (e.g., the total available harvest under each of the alternatives) would only occur if additional manufacturing facilities and markets are developed, as well as other factors such as funding and staff levels. In addition, we added a brief discussion that addresses the different time scales these effects could have on carbon sequestration as discussed in Environmental Consequences section. The net contribution to atmospheric CO2 is lower given longer time scales due to regeneration, particularly if wood products include 'storage' products, if

biomass substitutes for local fossil fuel use, and if market substitution (also called market leakage)is relatively high (e.g. Jonsson et al. 2012[8]).

COMMENT

CARB-022 and CARB-23: The climate change analysis in the DEIS is insufficient and lacks usage of the most recent science specific to southeast Alaska. Furthermore, in addition to the Secretary of Agriculture's direction on the purpose and need for the Forest Plan Amendment, that purpose and need should also include changes in forest management and health as a consequence of a changing climate. Additional references, including EPA data (www3.epa.gov/climatechange/impacts/alaska.html) and the 2014 National Climate Assessment (http://nca2014.globalchange.gov/report/regions/alaska#intro-section) should be used in the FEIS as well as include a quantification of GHG emissions from the proposed action and "appropriate" quantitative or qualitative analytical methods.

RESPONSE

See CARB-23 response for specific address of quantification of GHGs.

COMMENT

CARB-23: Disclosure of the magnitude of carbon emissions, carbon storage, and ultimately carbon sequestration should be presented more clearly in light of the literature and that the disclosure should also more clearly present the importance of carbon stores on the Tongass National Forest. The analysis in the DEIS downplays the emissions of carbon that result from timber harvest. A carbon life-cycle analysis should be presented to illustrate the outcome of the alternatives. An evaluation of the social cost of carbon emissions based on Executive Order 12866 and using the Interagency Working Group guidelines on carbon costing should be conducted.

THE DEIS had several shortcomings in disclosure of the relationship between ongoing climate change and the resilience of the temperate coastal rainforest and the potential role of the Tongass as a climate refuge for biodiversity associated with coastal rainforests. In particular, the analysis did not sufficiently examine the potential impact of harvesting old-growth (and young-growth forest in old-growth reserves) or harvest of beach buffers on the resilience of the forest in response to changing climate. The DEIS did not reference a communication On January 2015, from the Federal Forest Carbon Coalition to Secretary Vilsack, Beth Pendleton, and Forrest Cole asking that management of the Tongass National Forest align with the Administrations climate direction.

RESPONSE- A. Forest Carbon

We appreciate input suggesting a more clear disclosure of carbon emissions, storage and ultimately carbon sequestration on the Tongass National Forest. The FEIS more clearly illustrates the role of the Tongass National Forest in carbon sequestration and discloses the relative differences among alternatives in carbon storage and sequestration at multiple temporal scales.

A quantitative carbon life-cycle analysis has not been conducted and is not included in the analysis. CEQ recommends that agencies determine the appropriate level of action for NEPA review at which to more rigorously evaluate the effects of GHG emissions and climate change – whether broad programmatic, landscape scale, or at a project/site specific levels of NEPA (79 FR 77824 Dec. 24, 2014). CEQ further indicates that agencies continue to have substantial discretion in how they tailor their NEPA process (79 FR 77824 Dec. 24, 2014) and that agencies should apply the philosophy of 'proportionality' and 'rule of reason' to determine the extent to which a particular analysis or approach to evaluation is useful to the

[8] Jonsson, R., W. Mbongo, A. Felton, and M. Boman. 2012. Leakage implications for European timber markets from reducing deforestation in developing countries. Forests 3:736-744.

public and to the decision-making process for distinguishing between alternatives (79 FR 77824 Dec. 24, 2014).

We determined that a qualitative analysis comparing the relative contribution of alternatives to carbon emissions or storage was most appropriate for understanding tradeoffs. Therefore we do not present a quantitative carbon life-cycle analysis. We contend that project-level analysis is the appropriate stage of planning for a more rigorous evaluation of carbon in this case because of the substantial reduction in uncertainty at the project-level regarding the estimates for parameters of a carbon life-cycle analysis (e.g. sources and extent of emissions during harvest, environmental conditions related to carbon loss and carbon capture during forest regeneration, and potential use of the wood). Furthermore, the narrow scope of this action as an amendment to the Forest Plan precluded the option to explore action alternatives specifically designed to promote carbon sequestration. Thus, the principles of proportionality and the 'rule of reason' suggest that a quantitative carbon life-cycle analysis, particularly an analysis with high uncertainty, would not contribute toward evaluation and decision making. It is important to emphasize the high uncertainty in estimates of short- medium- and long-term carbon emissions, storage, and sequestration (or in a carbon life-cycle analysis) for any alternative (explained further below). Given the high uncertainty in the carbon life-cycle analysis compared to the relatively small differences among alternatives in carbon sequestration (particularly in the medium- and long-term), the results of the analysis would not inform the decision.

The high uncertainty in a carbon life-cycle analysis associated with this amendment results from the substantial range of potential values for most of the parameters in the carbon life-cycle analysis and therefore the array of final results. Adequate quantitative analysis must present the many estimates of carbon associated with the different parameter estimates resulting from different assumptions related to uncertainty. For example, following timber harvest a substantial quantity of organic material remains on site and decomposes over time. The decomposition rates and extent of decomposition depend on a broad array of factors and therefore different carbon life-cycle estimates result from differing assumptions regarding decomposition. A recent study identifies the lack of consensus in the science community on the temperature sensitivity of soil carbon decomposition to changes in regional temperature (Davidson and Janssens 2006). Many factors, including the relative mix of soil organic matter along a continuum of decomposability, and an array of environmental constraints (abiotic and biotic conditions) obscure the rate of soil organic decomposition (Davidson and Janssens 2006). This suggests that a clear evaluation of the rate and extent of soil carbon decomposition on the Tongass has high uncertainty and a variety of estimates are reasonable. A qualitative evaluation, however, leads to conclusions that substantially reduce uncertainty – soil carbon decomposition will increase with increasing temperature (expected with climate change) (D'Amore, pers. comm. 2016), and those amendment alternatives which harvest more extensive areas will have higher rates of carbon emissions in the short- and medium-term.

High uncertainty confounding quantitative analysis also occurs because of the range of reasonable estimates for other features (in addition to soil carbon). Uncertainty in rates of forest regrowth after old-growth and young-growth harvest on the Tongass, amounts of wood material remaining following harvest, transportation methods and distances for logs and wood products, use of the wood, market dynamics related to substitution (sometimes called market leakage – e.g. Jonsson et al. 2012)), and product substitution all confound a quantitative carbon life-cycle analysis (see McKinley et al 2011 for a broad overview of the complexity of carbon life-cycle analysis). A quantitative analysis would be both misleading in its rigor and perceived precision (if the substantial uncertainties where not taken into account) or confusing (if the range of uncertainty in important parameters was taken into account and the full range of resulting estimates displayed).

We have not provided a rigorous evaluation of the differences among alternatives in the social costs that may result from carbon emissions and resulting short- medium- or long-term contributions to GHGs. Given the high uncertainty in carbon emissions, and particularly the relatively small differences among alternatives in carbon emissions, an evaluation of social costs would be highly speculative and contrary to CEQ guidance (79 FR 77817 Dec. 24, 2014)

Although an estimate of carbon emissions can be calculated (as illustrated by one commenter), the uncertainty in any estimate must be disclosed and the relative merit in considering that estimate

evaluated based on the degree of uncertainty. As described earlier, evaluation of carbon emissions, particularly over the mid- and long-term, is highly uncertain and that uncertainty far exceeds the potential differences among alternatives in carbon storage.

RESPONSE - B. Climate Change

We appreciate the input regarding the reduced probability of fire, the role of the temperate coastal rainforest potentially serving as a climate refugia and the resilience of the temperate coastal rainforest. The revised EIS includes these concepts. We carefully considered the input from the letter from the Federal Forest Coalition on January 2015, and concluded that the resilience of the temperate coastal rainforest in SE Alaska is maintained through the system of reserves and other non-development LUDs and therefore the broad region of SE Alaska will continue to serve a strong role as a climate change refugia. Under all of the amendment alternatives The Tongass National Forest will continue to maintain large intact areas, larger than those evaluated under the 1997 plan, and therefore, as outlined in the EIS, will continue to play a strong role in supporting biodiversity as a climate refugia and a region with resilient forests.

Regarding the contention that the preferred alternative, or any alternative, does not align with Executive Branch guidance because management will not conserve carbon sinks by protecting them in perpetuity. CEQ guidance (79 FR Dec. 24, 2014) and Executive Order 13653 do not require such.

COMMENT

CARB-24 and CARB-7: The agency should adopt the conservation alternative (e.g. no harvest alternative), provided by the Conservation Consortium, to comport with CEQ guidelines, the Paris climate agreement, and efforts to reduce climate damages from CO2 pollution. The FEIS should also include a cost-benefit analysis of avoiding damages to the environment cause by climate change "so as to level the economic playing field" in compliance with Executive Order 12866.

RESPONSE

In response to comments regarding the importance of the Tongass Rainforest as Alaska's first line of climate change defense and the importance to the Paris Climate change agreement, we revised the FEIS to clarify the role the Tongass plays in global carbon sequestration. The analysis acknowledges the substantial role the Tongass plays in carbon storage and the role it will continue to play under each of the alternatives. The analysis qualitatively discloses that carbon storage on the Tongass will remain substantial under each alternative (while disclosing the relatively small differences among alternatives). Further, there is no present legal mandate to stop or limit timber sales based on the Paris Climate Change Agreement. Refer to CARB-23 for a more robust explanation of the global role of the temperate rainforest in carbon sequestration and the subsequent analysis we conducted. Additional discussion regarding the role of the Tongass in global carbon sequestration has been added to the text in Chapter 3 of the Final EIS.

Based on the scope of this amendment outlined in the 'Notice of Intent To Prepare An Environmental Impact Statement' published on 27 May, 2014, the purpose of the amendment is to: "accomplish the transition to young growth management over the next 10 to 15 years while retaining the expertise and infrastructure of a viable timber industry in Southeast Alaska, as outlined by the Secretary in Memorandum 1044–009." Commenters suggest that only a no-logging scenario maintains carbon stores through time and while that may be true, an alternative designed to meet this scenario is outside the scope of the EIS. As an amendment, rather than revision, the scope of options being considered does not include the potential for no timber harvest and therefore the consequences of such an alternative are not considered.

The global contribution of carbon storage that the Tongass provides is acknowledged in the Secretary of Agricultures memo to the US Forest Service in providing the scope and need for action to this Plan amendment. The Secretary's memo makes clear that the Department of Agriculture is committed to not only maintaining southeast Alaska's exceptional natural resources in perpetuity but is equally committed to doing its part to ensure that communities within and adjacent to the Tongass National Forest are economically vibrant. The proposed action for the Amendment is intended to bring these two goals hand

in hand. To do so, there will be costs and in the case of carbon storage we acknowledge that in order to bring to fruition the multiple-use objectives of this plan as well as the overall mission of the Forest Service, the Tongass will incur a short- and mid-term net loss of total carbon storage through GHG emissions as a result of timber harvest on the Tongass.

Regarding CEQ guidelines, the Paris climate agreement, and efforts to reduce climate damages from CO2 pollution, the agency (USDA) has not yet provided final guidance or policy directed at their implementation. Therefore, there is no present legal mandate to stop or limit timber sales based on the Paris Climate Change Agreements, nor to follow proposed draft CEQ guidance regarding NEPA. To date, guidance from the agency includes an analysis of climate for project NEPA (2009) and for Plan Revisions (2010). The CEQ cited by commenters is currently in DRAFT form and has therefore not been fully vetted as established policy. While the Revised DRAFT CEQ directs agencies to adopt projects with low emission using a reference point of 25,000 metric tons of CO2 (e) on an annual basis, the CEQ further indicates that agencies continue to have substantial discretion in how they tailor their NEPA process (79 FR 77824 Dec. 24, 2014) and that agencies should apply the philosophy of 'proportionality' and 'rule of reason' to determine the extent to which a particular analysis or approach to evaluation is useful to the public and to the decision-making process for distinguishing between alternatives (79 FR 77824 Dec. 24, 2014). For this EIS, a quantitative carbon life-cycle analysis has not been conducted and is not included in the analysis. CEQ recommends that agencies determine the appropriate level of action for NEPA review at which to more rigorously evaluate the effects of GHG emissions and climate change – whether broad programmatic, landscape scale, or at a project/site specific levels of NEPA (79 FR 77824 Dec. 24, 2014).

We determined that a qualitative analysis comparing the relative contribution of alternatives to carbon emissions or storage was most appropriate for understanding tradeoffs. Therefore we do not present a quantitative carbon life-cycle analysis as proposed in the revised DRAFT CEQ. We contend that project-level analysis is the appropriate stage of planning for a more rigorous evaluation of carbon in this case because of the substantial reduction in uncertainty at the project-level regarding the estimates for parameters of a carbon life-cycle analysis (e.g. sources and extent of emissions during harvest, environmental conditions related to carbon loss and carbon capture during forest regeneration, and potential use of the wood). Furthermore, the narrow scope of this action as an amendment to the Forest Plan precluded the option to explore action alternatives specifically designed to promote carbon sequestration. Thus, the principles of proportionality and the 'rule of reason' suggest that a quantitative carbon life-cycle analysis, particularly an analysis with high uncertainty, would not contribute toward evaluation and decision making. It is important to emphasize the high uncertainty in estimates of short- medium- and long-term carbon emissions, storage, and sequestration (or in a carbon life-cycle analysis) for any alternative (explained further below). Given the high uncertainty in the carbon life-cycle analysis compared to the relatively small differences among alternatives in carbon sequestration (particularly in the medium- and long-term), the results of the analysis would not inform the decision.

As well, the commenter suggests that the agencies' preferred alternative is generally inconsistent with the COP climate agreements (Article 4 on greenhouse sinks) to conserve forests as a sink for atmospheric carbon and is well above the CEQ emissions reference. However, the Revised DRAFT CEQ does not establish regulatory requirements or compel agencies to prohibit or curtail GHG emissions. In conformance with NEPA's basic principles, it does not mandate particular results or insist that agencies select the alternative with the least GHG emissions and climate change effects.

The commenter also suggests that "in any cost-benefit analysis, it is imperative to incorporate the benefits (or cost savings) of avoiding damages to the environment, or, in this case, the climate, so as to level the economic playing field (although many ecosystem services critical to properly functioning forests are difficult to quantify)". We have not provided a rigorous evaluation of the differences among alternatives in the social costs that may result from carbon emissions and resulting short- medium- or long-term contributions to GHGs. Given the high uncertainty in carbon emissions, and particularly the relatively small differences among alternatives in carbon emissions, an evaluation of social costs would be highly speculative and contrary to CEQ guidance (79 FR 77817 Dec. 24, 2014)

COMMENT

CARB-25: Forest Service should provide specific forest-wide goals, objectives and desired conditions for the Tongass National Forest in meeting challenges of climate change.

RESPONSE

Climate change is addressed in the Forest Plan in a number of ways. In the Implementation chapter, for example, “Our role in addressing climate change” is listed as one of five Tongass-wide high priority actions developed each year to guide project implementation. More importantly, climate change is incorporated extensively throughout the new Tongass National Forest Monitoring Program, released in May 2016.

Ecosystem Services (ECOS)

COMMENT

ECOS-1: Forest Service should define performance metrics for salmon production and the economic contribution that salmon produced by the Tongass. Additionally provide the amount of renewable energy supplied by the Tongass. Both of these should be measured as part of the Ecosystem Services that the Tongass provides.

RESPONSE

This request is beyond the scope of this Forest Plan Amendment. It is noted that a national effort is underway to define a new and improved suite of performance metrics.

Economics of the Timber Industry (ECON)

COMMENT

ECON-1: The EIS discussion of small log manufacturing should be updated to explain that the manufacturing of young growth spruce and hemlock trees will not be financially feasible until the trees are at least 90 years old or until there are sufficient acres of 60-year old and older trees available to enable the amortization of a modern small log sawmill. The proposed alternatives would provide less than 10 percent of the volume necessary to supply a single local small log mill and the trees are too small to be profitably sawn in the existing sawmills. Most of the logs cut from these trees will be exported in unprocessed form and will not support local manufacturing jobs. The Forest Service should continue with the current Forest Plan and allow the young growth stands to grow for another 30 years at which time the trees will be larger and more valuable, and the volume will have doubled.

RESPONSE

Table 3.13-4 in the *Timber* section of the FEIS displays the acres of harvested even-aged young-growth forest by age class and LUD group. This section of the FEIS also describes young growth management on the Tongass and provides an overview of the direction provided in the Secretary of Agriculture's Memorandum 1044-009. Among other things, the Secretary directs the Forest Service to "(s)eek opportunities to supply sufficient old-growth "bridge timber" while the industry re-tools for processing young growth". All of the alternatives evaluated in the Draft EIS include old-growth "bridge timber" and provide for a PTSQ that is a mix of old-growth and young-growth timber in the short-run, with old growth decreasing as a share of this total volume (46 MMBF) over time as more young growth becomes economic to harvest.

The results of the financial analysis prepared for the FEIS indicated that, viewed over 25-year and 100-year planning horizons, all five alternatives resulted in positive net revenues (Table 3.22-16, p. 3-482). Positive values for the 5-year increments that comprise years 1 to 25 were in most cases due to the old-growth component of projected harvest, which generated net positive revenue for all alternatives and 5-year increments over the 25-year planning horizon. In contrast, in most cases net revenues generated by the young-growth component were negative (Figure 3.22-18, p. 3-483).

As discussed in the FEIS, this programmatic analysis suggests that individual timber sales offered under any of the alternatives in the first 25 years of the planning period will likely need to include a mix of old growth and young growth to appraise positive as required by Public Law 112-74, House Report 2055-257, Section 414. However, over time, the young-growth component also generates positive revenues under all alternatives, which is reflected in the discounted net revenues presented for the 100 year planning horizon in Table 3.22-16.

The financial analysis has been revised in the FEIS to more clearly explain what is included in this analysis. The estimates presented in the FEIS have also been updated in the FEIS. More detailed discussion of the modeling approach and the assumptions and values used to develop these estimates is provided in FEIS Appendix B Modeling and Analysis, which has also been updated. The results of the Woodstock modeling are used for the purposes of analysis in the FEIS and represent the best information available at this time. The timber demand study (Daniels et al. 2016) used to estimate the PTSQ of 46 MMBF are long-term projections that represent estimated demand for the planning cycle, also used in the FEIS for the purposes of analysis. The Forest Service will continue to evaluate annual market demand using the Morse methodology and may adjust the mix of old-growth and young-growth timber made available for sale on a year-to-year basis, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry.

The suggestion in the comment that the Forest Service continue to manage the Tongass under the 2008 Forest Plan and offer primarily old-growth timber sales for the next 30 years, while allowing young-growth stands to increase in age and size, does not meet the purpose and need of the proposed Forest Plan amendment.

COMMENT

ECON-2: Young growth timber is typically used for low value construction lumber. In order to compensate for the low value, new small log mills tend to rely on high volume processing and proximity to both their timber supply and markets. A young growth facility in Southeast Alaska would be at a competitive advantage due to the relative high cost and uncertainty of the timber supply and distance to markets. Viking Lumber has indicated they could process up to 8 to 10 MMBF of small logs over a period of several years, provided they are able to maintain full operations of their old-growth saw mill.

RESPONSE

As discussed in response to ECON-1, all of the alternatives evaluated in the Draft EIS include old-growth "bridge timber" and provide for a PTSQ that is a mix of old-growth and young-growth timber in the short-run, with old growth decreasing as a share of this total volume (46 MMBF) over time as more young growth becomes economic to harvest. As indicated in the comment and discussed in the FEIS, Viking Lumber's current small log line processes approximately 8 MMBF of logs annually, running one shift per day, 40 hours per week.

The exact transition trajectory cannot be predicted. Our EIS predictions are best on the best information we have available. If it turns out that young growth does not sell as fast as expected due to markets and economics, then a greater proportion of old growth could temporarily be included in the sale to make up for the deficit. While this continues, existing young-growth stands will be growing and the shelf volume for young growth will continue to grow.

COMMENT

ECON-3: The Daniels et al. (2016) study assumes that "existing mills will make any machinery upgrades necessary for the young growth transition, but rates of utilization may fluctuate". This is a poor assumption. The projected supply of young-growth timber is too small to support the investment necessary to construct a small log sawmill, which will cost more than $100 million. Small log mills in Arkansas, Florida, and another proposed for Washington State have respective annual capacities of 387 MMBF, 700 MMBF, and 200 MMBF.

RESPONSE

The assumption cited in the comment from Daniels et al. pertains to their Scenario 1, which is summarized in the Draft EIS (starting on p. 3-458) and discussed in detail in Daniels et al. (2016). Despite this assumption Daniels et al.'s Scenario 1 projects that timber demand would decrease relative to the baseline projections following the young-growth transition in 2025, as the transition would in effect result in a reduction in Pacific Rim demand for lumber processed in Southeast Alaska.

The annual capacities of the small log mills cited in the comment are larger than those identified in the Draft EIS. The Beck Group (2009), for example, identified sawmills in the coastal regions of Oregon and Washington that currently process western hemlock for framing lumber production, using comparable equipment configurations as Viking Lumber to process logs of comparable size and quality. They found that these generally comparable sawmills processed on average 23 MMBF of logs per year, based on operating a single shift per day (Beck Group 2009). Another example of the type of facility that could be developed to process young-growth timber in Southeast Alaska, the Vaagen Brothers mill in Colville in eastern Washington, produced a total of 273 MMBF of lumber in 2014, of which 135 to 140 MMBF was also sawn at the Colville mill.

COMMENT

ECON-4: The timber industry in Southeast Alaska has lost its economy of scale and much of the related infrastructure required to support a competitive industry. In the face of this decline, the remaining mills have been able to remain competitive by selling high value products that cannot be produced from young-growth timber.

RESPONSE

As discussed in response to ECON-1, all of the alternatives evaluated in the Draft EIS include old-growth "bridge timber" and provide for a PTSQ that is a mix of old-growth and young-growth timber in the short-run, with old growth decreasing as a share of this total volume (46 MMBF) over time as more young growth becomes economic to harvest. Old-growth volume would continue to decrease until it reaches 5 MMBF per year, at which point it would be stabilized at 5 MMBF per year to support a small sale and micro sale industry, and would remain at that level for the remainder of the planning period.

COMMENT

ECON-5: As currently scheduled, the Forest Plan will be amended before the Forest Service has completed the necessary studies to confirm the volume of young-growth timber available for harvest, the cost of harvesting young growth stands that are small and widely scattered, or confirm that it will be financially viable for a young-growth industry to develop and find markets for its products based on that volume. In the absence of this and other information that proves that a transition to young-growth can happen sooner than the industry's expectation of 30 years, it is inappropriate for the plan amendment to be proposed.

RESPONSE

As discussed in response to ECON-1, all of the alternatives evaluated in the FEIS include old-growth "bridge timber" and provide for a PTSQ that is a mix of old-growth and young-growth timber in the short-run, with old growth decreasing as a share of this total volume (46 MMBF) over time as more young growth becomes economic to harvest.

The Woodstock modeling analysis conducted in support of the Forest Plan amendment indicated that initially, older young growth stands can be harvested economically when combined with old-growth. The Woodstock model tracks the growth of young-growth stands over time and does not select stands for harvest until it is economical. This analysis is discussed in detail in the revised Appendix B to the FEIS.

In general, the results of the financial analysis prepared for the FEIS indicated that, in most cases, net revenues generated by the young-growth component in 5-year increments for the first 25 years following implementation would be negative. However, over time, the young-growth sale component would also be expected to generate positive revenues. The Forest Service will continue to evaluate annual market demand using the Morse methodology and may adjust the mix of old-growth and young-growth timber made available for sale on a year-to-year basis, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry.

Our analysis indicates that initially, older young growth stands can be harvested economically when combined with old-growth. The Woodstock model used tracked the age and growth of young-growth stands and did not select stands for harvest until they reached 65 to 75 years of age, depending on site class. These ages were based on discussions with industry who confirmed that minimum age required that two logs per tree could be obtained from the majority of trees in a stand and an evaluation of stand tables to determine what ages this occurred.

See response P&N-4 (Young growth Inventory)

COMMENT

ECON-6: Appendix B of the Draft EIS implies that new class/site index data was estimated and used to model wood availability, but no new field surveys were conducted to verify the accuracy of this site index information. Until these site index data are verified, it is impossible for the Forest Service and others to have faith in the accuracy of the estimates presented in the Draft EIS. The Forest Service, acting on the TAC recommendations, proposed in July 2015 to fund up to $4 million of studies to update the inventory of young-growth by location and to develop better data on the growth rates of young-growth trees. This study is unlikely to be completed prior to finalization of the new Forest Plan and is unlikely to produce the quality data necessary to forecast the forest-wide availability of young-growth timber.

RESPONSE

The Challenge Cost-Share agreement between the State of Alaska and the US Forest Service, which began in 2016, will inventory approximately 50,000 acres of young-growth timber to provide knowledge about the conditions and feasibility of the older young-growth timber stands. This inventory will also note logging systems needed to access these stands. This agreement has been already been funded. The transition timeline for the action alternatives proposed in the amendment is designed to accelerate this data collection on young-growth harvest by providing more opportunities to harvest the older young growth sooner than the 2008 Forest Plan direction allows. The Forest Service will continue to evaluate annual market demand using the Morse methodology and may adjust the mix of old-growth and young-growth timber made available for sale on a year-to-year basis, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry.

COMMENT

ECON-7: The financial analysis presented in the Draft EIS significantly overstates the likely value of the proposed timber volume to a purchaser. The Forest Service has only been able to achieve similar returns on about one-quarter of the old-growth timber sale volume planned each year, with three-quarters of planned timber sale volume never offered because it was not economic to harvest under the 2008 Forest Plan. The Draft EIS analysis anticipates a fourfold increase in returns, even though the Forest Service proposes to sell increasing volumes of lower value, young-growth timber.

RESPONSE

The financial analysis in the Draft EIS has been revised to more clearly explain what is included in this analysis. The estimates presented in the Draft EIS have also been updated. More detailed discussion of the modeling approach and the assumptions and values used to develop these estimates is provided in Appendix B to the EIS, which has also been updated.

The numbers reported in the financial analysis are derived from the Woodstock modeling conducted in support of the proposed Forest Plan amendment. As discussed in the Draft EIS (p. 3-481):

> Positive values for the 5-year increments that comprise years 1 to 25 are in most cases due to the old-growth component of projected harvest. The old-growth component generates net positive revenue for all alternatives and 5-year increments over the 25-year planning horizon (Figure 3.22-17). In contrast, in most cases net revenues generated by the young-growth component are negative (Figure 3.22-18).
>
> This programmatic analysis suggests that individual timber sales offered under any of the alternatives in the first 25 years of the planning period will likely need to include a mix of old growth and young growth to appraise positive as required by Public Law 112-74, House Report 2055-257, Section 414.

COMMENT

ECON-8: The financial analysis presented in the Draft EIS indicates that all plan alternatives have a positive net present value. In the absence of information on the cost of young-growth harvest and the potential products that will be manufactured from young-growth timber and associated costs and profits, it is impossible to accept that these estimates, which are based on conditions in the Lower 48 states, are potentially accurate. These estimates also fail to account for reductions in the value of productive old-growth when sale areas decrease in size and production costs rise.

RESPONSE

The costs and revenues associated with the young growth harvesting and manufacture were developed by a private consultant based on young growth in as similar as possible conditions in the Lower 48 states and adjusted for Southeast Alaska conditions. The Alaska region cost collection process will, over time, provide more refined costs and revenues to be used in the appraisal process. The Forest Service will

continue to evaluate annual market demand using the Morse methodology and may adjust the mix of old-growth and young-growth timber made available for sale on a year-to-year basis, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry.

COMMENT

ECON-9: The Draft EIS cites the Nature Conservancy's 2009 Beck report but fails to report that the Beck Group found that a small log manufacturing operation would be uneconomic unless the Forest Service subsidized the associated logging costs. In addition, the Alaska Forest Association reportedly identified several errors in the Beck Group analysis, which resulted in the costs to establish and operate a small log mill being significantly understated.

RESPONSE

The Draft EIS cites the referenced study prepared for the Nature Conservancy by the Beck Group (2009) in a number of ways, including the Beck Group's evaluation of the small log line at the Viking saw mill and their general characterization of the other mills currently operating on Prince of Wales Island. The Draft EIS also cites the Beck Group's (2009) finding that sawmills in the coastal regions of Oregon and Washington that currently process western hemlock for framing lumber production, using comparable equipment configurations as Viking Lumber, processed on average 23 MMBF of logs per year, based on operating a single shift per day. The Draft EIS does not use the findings of the Beck Group report to illustrate or support the economic feasibility of a young growth mill.

COMMENT

ECON-10: Processing logs and producing finished products represents a substantial component of a logs value. How will continued large-scale log export support the development of a sustainable and vibrant pool of small-scale, local wood processors?

RESPONSE

The purpose and need for the Forest Plan amendment responds to the July 2, 2013 memorandum from USDA Secretary Tom Vilsack which specifically directs the US Forest Service to expedite the transition from old-growth to young-growth timber harvest while maintaining a viable timber industry that provides jobs and opportunities for Southeast Alaska residents. Among other things, the Secretary directs the Forest Service to "(s)eek opportunities to supply sufficient old-growth "bridge timber" while the industry re-tools for processing young growth" (Draft EIS, p. 3-297). All of the alternatives evaluated in the Draft EIS include old-growth "bridge timber" and provide for a PTSQ that is a mix of old-growth and young-growth timber in the short-run, with old growth decreasing as a share of this total volume (46 MMBF) over time as more young growth becomes economic to harvest.

The limited timber export policy and the young-growth transition are discussed in response to TEXP-3. As indicated in this response, the Forest Plan amendment is designed to analyze the feasibility of shifting from an old-growth forest management regime towards young growth management. How rapidly and effectively this is accomplished depends on local support from Alaska markets for young-growth forest products. The ability to export some timber beyond Alaska may serve as a strategic option that can be used to help maintain workforce skills, industry expertise, and the physical infrastructure needed to develop a future young-growth industry. The limited shipment policy will continue to be subject to review and modification on an annual basis, as noted above.

Public Costs (PUBC)

COMMENT

PUBC-1: The Draft EIS does not present the estimated costs and revenues to the U.S. Treasury associated with the proposed alternatives. Instead the Draft EIS presents estimated values to the purchaser (selling value minus costs for logging, transportation, manufacturing, profit, and risk), which are misleadingly identified as net revenues. The Final EIS must present actual past and expected future costs and revenues to the U.S. Treasury for the Tongass timber program.

RESPONSE

The financial analysis section in the Draft EIS has been revised to more clearly explain what is included in the analysis, with additional information provided in Appendix B Modeling and Analysis, which has also been revised. In addition, the revised financial analysis includes estimated Forest Service administrative costs per MBF and provides an estimate of net agency revenues (timber sale revenues minus timber variable costs).

Evaluating the past and expected future costs and revenues associated with the overall Tongass timber sale program is outside the scope of this Forest Plan amendment. Information on Tongass program administrative costs and revenues is, however, readily available to the public in the annual State of the Tongass National Forest report prepared by the Forest Service. The most recent version available online is for Fiscal Year (FY) 2013 (USDA Forest 2014). More recent information is available upon request.

COMMENT

PUBC-2: The net revenues presented in the Draft EIS represent the estimated values to the purchaser (selling value minus costs for logging, transportation, manufacturing, profit, and risk), and should, therefore, reflect the prices purchasers should be paying for Tongass timber. Data from the Draft EIS analysis indicates that the Forest Service is estimating pond log values of $351 per thousand board feet (MBF), which substantially exceeds the actual 5-year average from 2011 to 2015 of $57 per MBF. Neither the Draft EIS nor the planning record provide the assumptions used to develop these estimates, displaying only the final model outcomes. The Final EIS needs to more fully explain these estimates.

RESPONSE

As noted in response to PUBC-1, the financial analysis in the Draft EIS has been revised to more clearly explain what is included in this analysis. The estimates presented in the Draft EIS have also been updated. More detailed discussion of the modeling approach and the assumptions and values used to develop these estimates is provided in Appendix B Modeling and Analysis to the EIS, which has also been updated.

COMMENT

PUBC-3: The Draft EIS improperly excluded a detailed public investment analysis that disclosed the full cost of the Tongass timber program, including logging road costs, agency timber program administrative costs, the costs of timber program-related restoration projects, and NEPA costs. The Draft EIS also failed to estimate the costs, monetary and otherwise, on other forest values and users, including carbon storage, recreation and tourism, fisheries, and ecosystem services. NEPA requires that the agency provide at least a broad, informal cost benefit analysis of the proposed action, and CEQ regulations require that this analysis include discussion of the relationship between the analysis and any analysis of unquantified environmental impacts, values and amenities.

RESPONSE

As noted in response to PUBC-1, a detailed public investment analysis of the Tongass timber program is outside the scope of this Forest Plan amendment. Information on Tongass program administrative costs

and revenues is, however, readily available in the annual State of the Tongass National Forest report prepared by the Forest Service. In addition, the financial analysis section in the Draft EIS has been revised to include an estimate of net agency revenues (timber sale revenues minus timber variable costs) by alternative.

The Draft and Final EIS documents were prepared under the 2012 planning rule, which "does not include requirements to demonstrate that plans will maximize net public benefits or require valuation of economic efficiency or require present net value analysis as the 1982 rule did" (Federal Register [FR], Vol. 77, No. 68, 21187). The preamble to the Final 2012 planning rule and record of decision (FR, Vol. 77, No. 68, 21188), further notes that the:

> "Forest Service Handbook (FSH 1909.15.section 22.32) as well as NEPA regulations (40 CFR 1502.23) state that for purposes of complying with the [NEPA], the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations."

The handbook and NEPA regulations do, however, state that an EIS should indicate those considerations that are likely to be relevant and important to a decision, which may "include a variety of quantified or qualitative descriptions of costs and benefits that are linked to significant issue determinations for a particular forest plan" (FR, Vol. 77, No. 68, 21188). The Draft and Final EIS documents provide a detailed and extensive assessment of the effects of the alternatives on non-timber forest values and user groups. As discussed in the Draft EIS with respect to ecosystem services (p. 3-487):

> The effects of the alternatives on these types of services including the sections of the EIS that address watersheds, fisheries, soils, wildlife and subsistence use, heritage resources, and timber and vegetation, among others. Monetary values are not assigned to these services, but this does not lessen their importance in the decision making process.

In addition, as referenced in the Draft EIS (p. 3-487), ecosystem services are discussed at the forest planning level for the Tongass National Forest in the 2008 Forest Plan EIS (USDA Forest Service 2008b, p. 3-544 to 3-556).

COMMENT

PUBC-4: The Forest Plan amendment goes to great lengths to support about 200 timber jobs rather than allocating the associated funds to the fishing and tourism industries that support thousands of jobs. The Forest Service should take a "hard look" at this allocation and recognize the monetary and societal value of other forest uses, as well as seek ways to improve protections for fish and wildlife habitat and enhance visitor services.

RESPONSE

The management alternatives presented in the EIS are all designed to support sustainable levels of tourism and fishing. The *Economic and Social Environment* analysis presented in the EIS discusses the monetary and societal value of other forest uses at some length, including recreation and tourism, commercial fishing, mining, and the economic value of natural amenities and quality of life. The *Economic and Social Environment* section also addresses the potential impacts to these resources, as well as other non-value uses including passive use values and ecosystem services.

Under the current Forest Plan, Forest Service programs currently emphasize protection for fish and wildlife habitat and seek ways to enhance visitor services. These protections will remain in place in the proposed Forest Plan amendment, and the Forest Service will continue to work with other regional groups to develop visitor services, as appropriate.

Many factors affect the availability of public sector funds for multiple program areas. Consideration of funding strategies and resource allocation is outside the scope of this forest plan amendment and EIS.

Socioeconomics (SOC)

COMMENT

SOC-1: The Draft EIS acknowledges that the Tongass timber sale program causes significant adverse effects to the environment, but makes no attempt to evaluate the economic costs of these impacts, and disregards the extensive literature that discloses the economic value of non-timber forest uses, including hunting and wildlife viewing.

RESPONSE

The Draft EIS discusses the contribution of the timber and other natural resource-based industries to the regional economy in the *Economic and Social Environment* section. In addition to timber, this section provides a detailed discussion of the recreation and tourism, commercial fishing and seafood processing, and mining and mineral development sectors, and also addresses the importance of quality of life and natural amenities in attracting and retaining residents and businesses. Further, the *Communities* subsection of the Draft EIS provides detailed information on employment and economic conditions by community. Potential impacts to the regional economy are also assessed in the *Economic and Social Environment* section, including potential impacts to the timber, recreation and tourism, and commercial fishing and seafood processing sectors, as well as quality of life and natural amenities.

COMMENT

SOC-2: Contrary to federal policy, the Draft EIS makes no attempt to address the social costs of carbon dioxide released as a result of timber harvest. Federal agencies, including USDA and the Forest Service, have calculated the social costs of carbon from other federal land management actions.

RESPONSE

Additional discussion regarding the social costs of carbon has been added to the *Climate Change* section in the Final EIS.

COMMENT

SOC-3: The Draft EIS (pg. 3-441) appears to suggest that harvesting old-growth timber has negative impacts on tourism. This is a false assumption. Continued timber harvest and road development will enhance tourism.

RESPONSE

The text from the Draft EIS quoted in the original text of the above comment is part of a general introductory paragraph that addresses three different types of broad value: recreation and tourism; ecosystem values; and non-use values. The paragraph does not address the relationship between timber harvest and tourism. Potential impacts to recreation and tourism are evaluated in the *Recreation and Tourism* section of the Draft EIS, and the associated economic impacts are addressed in the *Social and Economic Environment* section.

COMMENT

SOC-4: The Draft EIS fails to show how the proposed alternatives will meet the goal of providing jobs for Southeast Alaska residents because the timber industry accounts for only a small share of regional employment. The Draft EIS fails to consider the impact of the limited export policy on the number of saw mill jobs supported per MMBF harvested, the share of logging jobs held by non-residents, or the potential for young growth logging to employ fewer workers due to increased mechanization, making it impossible to evaluate whether the proposed timber harvest levels will meet the goal of providing jobs for Southeast Alaska residents.

RESPONSE

Concerns regarding the scope of the Purpose and Need are addressed in detail in the *Purpose and Need* section of this comment response document (see, for example, P&N-10). The purpose and need for the amendment responds to the July 2, 2013 memorandum from USDA Secretary Tom Vilsack which specifically directed the US Forest Service to expedite the transition from old-growth to young-growth timber harvest while maintaining a viable timber industry that provides jobs and opportunities for Southeast Alaska residents.

Diversity of employment opportunities is important for any economy especially in small towns. The *Communities* section of the Draft EIS inventories estimated employment, by industry sector, for each community. Some small towns, such as Thorne Bay, are more focused on timber employment than others such as Skagway, where the economy is more based on tourism. In addition, transitioning to young growth timber management may disperse these jobs across the region. The oldest young growth is in the northern part of the Tongass National Forest, which may create possible niche markets in that subregion.

Concerns related to the limited timber export policy are addressed in detail in the Timber Export subsection of this comment response document. The comment notes that the sawmill jobs per MMBF harvested on the Tongass have declined since 2008 when the limited timber export policy was initiated, dropping from an average of 2.2 jobs/MMBF (2002 to 2007) to an average of 1.5 jobs/MMBF (2009 to 2014). This does not, however, capture the entire picture, as exporting unprocessed timber supports a different range of jobs than domestic processing with more of an emphasis on transportation and stevedoring than sawmilling. This is reflected in the estimated timber industry employment and income estimates presented by alternative in Table 3.22-18 in the Draft EIS (p. 3-484). As noted in footnote 5 to this table, export employs more workers in transportation and other services per MMBF harvested than domestic production. Transportation and other services for export volume include water transportation, independent trucking, stevedoring, scaling, and export marking and sort yard employment for export volume. Transportation and other services for locally sawn volume include water transportation, scaling, and independent trucking.

Local sawmilling and transportation-related employment estimates presented in Table 3.22-18 are based on a range, from maximum possible shipment out of state (export of all Alaska yellow cedar plus hemlock and Sitka spruce export equal to 50 percent of total sale net sawlog volume), to no shipment of hemlock and Sitka spruce and export of 100 percent Alaska yellow cedar (see Table 3.22-18, footnote 4).

Non-resident employment in Southeast Alaska is discussed in the *Economic and Social Environment* section of the Draft EIS and summarized in Figure 3.22-2. Alaska currently employs a significant quantity of seasonal workers in resource-dependent industries because of the nature of this employment and the weather conditions. Nonresident workers as a share of direct employment in resource-dependent industries in Southeast Alaska range from 39.5 percent in the leisure and hospitality sector to 71.3 percent in the manufacturing sector (which mainly consists of employment in the seafood processing sector) (Figure 3.22-2). Many workers leave in the winter either because employment ends (i.e., tourist season ends) – or, they prefer to spend their wages somewhere where the cost of living is lower than Alaska. These are seasonal workers that do not become year-around residents.

Transitioning to young-growth timber harvest may result in a different range of types of employment than the current mix. Mechanical harvesters, for example, were they to be employed, require different maintenance, repair services, and transportation than conventional harvesting.

COMMENT

SOC-5: The Draft EIS fails to appreciate the full economic impact of commercial fishing. The ex-vessel value reported in the Draft EIS fails to account for the economic impact of in-state processing and the various goods and services provided to the fish harvesting and processing industries. The Draft EIS also fails to accurately identify the number of jobs provided by commercial and sport fishing. The economic value of commercial and sport fishing should be balanced against the value of logging.

RESPONSE

The text cited in this comment is from the introduction to the *Fish* section of the Draft EIS. The economic impacts associated with commercial fishing are described in more detail in the *Economic and Social Environment* section in Chapter 3 of the Draft EIS. A note referring the reader to the *Economic and Social Environment* section has been added to the introduction to the *Fish* section to avoid confusion. Direct employment in natural resource industries is, for example, compared in Table 3.22-3 and Figure 3.22-1, and a detailed discussion of the commercial fishing sector is provided in the subsection entitled *Commercial Fishing and Seafood Processing* (starting on p. 3-465 of the Draft EIS).

COMMENT

SOC-6: The Draft EIS indicates that the proposed alternatives would likely have negative effects on subsistence, but provides no information on the role that subsistence plays in communities or the socioeconomic importance of these potential adverse effects. There is a wealth of information on the topic, much of which has been developed by or with the cooperation of the Forest Service. Much of this information is available through the ADF&G, Division of Subsistence.

RESPONSE

The Draft EIS includes a substantial amount of information regarding subsistence activities including detailed analysis for each community within the region (see pp. 3-501 through 3-656). The Forest Service is aware that ADF&G has expertise in and publishes data and information on subsistence resources and activities. ADF&G subsistence data and information, including some developed by the Forest Service, is provided, cited, and discussed at length throughout the Draft EIS. In addition to publicly available data, ADF&G also provided the more detailed data used for the community-level analyses (pp. 3-501 through 3-656).

COMMENT

SOC-7: The Draft EIS indicates that the proposed alternatives would likely have negative effects on hunting, fishing, and wildlife-viewing, but provides no information about the economic importance of these activities. The Draft EIS should have cited the results of a report prepared for ADF&G that assessed the economic importance of wildlife in 2011 (ECONorthwest 2014).

RESPONSE

The economic importance of hunting, fishing, and wildlife-viewing is discussed in the *Economic and Social Environment* section of the Draft EIS starting on page 3-463 under *Recreation and Tourism*. Additional information from the report cited in the comment has been added to this section in the Final EIS.

COMMENT

SOC-8: The Draft EIS fails to assess the importance of resource-related amenities, such as access to fish, wildlife, and scenic unlogged forests, to the quality of life for local residents and the role these resources play in attracting and retaining residents and businesses. While these issues are discussed in the Draft EIS, the Draft EIS analysis is deficient because it does not include survey results from a report prepared for ADF&G that found that quality of life issues are important to many Southeast Alaska residents (ECONorthwest 2014). In addition, the Draft EIS fails to consider the impact of the alternatives on quality of life issues.

RESPONSE

The Draft EIS discusses the importance of resource-related amenities, such as access to fish, wildlife, and scenic unlogged forests, to the quality of life for local residents and the role these resources play in attracting and retaining residents and businesses in the *Economic and Social Environment* section of the Draft EIS starting on page 3-468 under *Natural Amenities and Quality of Life*. Potential impacts to quality of life issues are discussed in the Environmental Consequences part of the *Economic and Social Environment* section of the Draft EIS starting on page 3-486 under *Natural Amenities and Quality of Life*.

Additional information from the report cited in the comment has been added to this section in the Final EIS.

COMMENT

SOC-9: The Draft EIS would have presented a more complete portrait of the potential socioeconomic impacts of the alternatives if it had provided information about the net economic benefits local residents and visitors derive from wildlife, fish, scenery, and other resources. Specifically, the Draft EIS should have included information from a report prepared for ADF&G that assessed the economic importance of wildlife in 2011 (ECONorthwest 2014). In addition, the Draft EIS does not address the potential impacts of the alternatives on ecosystem services.

RESPONSE

The report referenced in the comment provides estimates of the "net economic benefits" of hunting and wildlife viewing for residents and visitors in Alaska in 2011. Net economic benefits as presented in this report include the amount residents and visitors spent on these activities plus a hypothetical amount they would have been willing-to-pay above the amount they actually did pay. In addition, the estimates also included the estimated amount survey respondents would theoretically be willing-to-pay to visit an area managed to ensure they would see a specific species and the amount they would be willing-to-pay into a wildlife conservation fund. The resulting estimates are, of course, considerable and provide an indication of the importance of wildlife to residents and visitors to Alaska. These types of non-use values (i.e., values that individuals assign to a resource independent of their use of that resource) are discussed further in the 2008 Forest Plan EIS (USDA Forest Service 2008b, p. 3-551 to 3-552).

The Draft EIS provides an overview of ecosystem services and references the detailed discussion in the 2008 Forest Plan EIS (USDA Forest Service 2008b, pp. 3-544 to 3-556). The discussion in the current Forest Plan EIS is located in the *Economic and Social Environment* section of the Draft EIS on page 3-487 under *Ecosystem Services*. The author of the above comment notes that there are many good introductions to the values of services derived from forest ecosystems and provides a list of references for the Forest Service to consider. Many of these references are included in the discussion in the 2008 Forest Plan EIS, which is incorporated in the current EIS, as noted above.

COMMENT

SOC-10: The Draft EIS does not assess the economic impacts and costs to businesses and communities in the event that the young-growth transition is not successful and existing timber operations go out of business. If Viking Lumber were to go out of business, for example, AP&T would experience a significant reduction in energy demand on Prince of Wales Island. This could potentially lead to a so-called "death spiral" whereby a drop in sales leads to an increase in rates to cover fixed costs, which in turn leads to further sales reductions.

RESPONSE

The purpose and need for the amendment responds to the July 2, 2013 memorandum from USDA Secretary Vilsack which directed the US Forest Service to expedite the transition from old-growth to young-growth timber harvest while maintaining a viable timber industry that provides jobs and opportunities for Southeast Alaska residents. All of the alternatives, including No Action, are designed to expedite this transition. The amended Forest Plan under all alternatives would provide an annual average of 46 MMBF during the transition period and it is up to the industry to respond to the transition. The transition time frame provides opportunity for the existing industry to adjust or retool for a predominantly young-growth supply from the Tongass, as well as time for new operations to develop, if appropriate.

COMMENT

SOC-11: The Final EIS should identify the number of jobs that would be created for industry maintaining and decommissioning existing forest roads. Unlike the Draft EIS alternatives, this type of emphasis would create long-term, sustainable employment for timber industry workers.

RESPONSE

The Draft and Final EIS documents include five alternatives designed to meet the Purpose and Need for the Forest Plan amendment, as directed by the Secretary of Agriculture. This is explained further in the Purpose and Need section of the Draft EIS, starting at page 1-4. An alternative that does not include timber harvest would not meet the Purpose and Need. Information related to road maintenance and proposed decommissioning on the Tongass National Forest is available in the Access Travel Management Plans prepared for each Ranger District. These plans are available at the District offices.

Market Demand (MKD)

COMMENT

MKD-1a: The PNW Research Station demand study overestimates the likely actual demand for timber. All three scenarios evaluated in the study ignore the long-term decline in market demand and anticipate increasing demand over the next 15 years. These scenarios rely on misleading assumptions about the U.S. share of global timber markets, the portion of this share accounted for by federal harvest in Southeast Alaska, and in particular the assumption that the Tongass will retain the same share it currently has of rising global demand. The Forest Service should recognize that this approach has failed to accurately predict demand in the past, and consider a scenario that involves a continued decline in demand.

RESPONSE

During the past 25 years, the U.S. Forest Service, Pacific Northwest (PNW) Research Station has published several studies in support of Tongass National Forest land management planning that estimate derived demand for Southeast Alaska timber including Brooks and Haynes (1990, 1994, 1997), Brackley et al. (2006a), and Daniels et al. (2016). Daniels et al. (2016) is the fifth such analysis performed since 1990 to assist forest planners in meeting statutory requirements for estimating planning cycle demand for timber from the Tongass National Forest.

Projections of Alaska timber products outputs, the derived demand for logs, lumber, residues, and niche projects, and timber harvest by owner are developed using trend-based projections. “Derived demand”, in PNW Research Station studies, is defined as the volume of national forest harvest needed to meet projected consumption of Alaska forest products, over time, given the harvest levels of other owners and based on assumptions about product markets. Similar to prior studies, Daniels et al. (2016) estimate demand for Tongass National Forest timber using a materials balance approach based on forecasted trends in product markets. Projected harvest from the Tongass National Forest is calculated as the volume of timber required to meet the shortfall between projected demand and harvest from other ownerships, primarily Native Corporation and State of Alaska lands. Alternatively stated, derived demand for Tongass National Forest timber is computed as the residual – the quantity of national forest timber required to balance the market.

Demand for Tongass National Forest timber depends on final markets supplied by Alaska forest products. The PNW Research Station identified all markets receiving Alaska wood products including utility logs, softwood lumber, mill residue, and other niche products. Additional information was gathered regarding production, shipments, and relative scale of markets served. This information was combined with projections of total wood product consumption (for domestic markets) or imports in destination regions to arrive at the share of the market supplied by Southeast timber production. Historic market data was collected and assessed for each product market including softwood log exports, domestic log market, utility logs, lumber, and other products.

The PNW Research Station then developed a baseline model based on the assumption that the industry in southeast Alaska production would remain at post-2008 recession levels for the next 15 years, despite indications at the time the study was completed (summer 2015) that U.S. sawnwood consumption had reached levels approaching those seen during the pre-recession housing boom (Daniels et al. 2016). The baseline model was subsequently used to evaluate three scenarios representing different potential futures for timber harvest in Southeast Alaska. The first scenario (Scenario 1) assumed that the transition to young growth would occur by 2025, with old-growth harvest constrained to 5 MMBF for small sales and micro-sales from that point onward. As modeled, this scenario resulted in a reduction in Pacific Rim demand for dimensional lumber from Southeast Alaska that would in turn cause a decline in harvest from the Tongass relative to the baseline rate. The second scenario built upon the transition modeled in Scenario 1 by adding an expansion of bioenergy markets. Scenario 3 also built on the transition modeled in Scenario 1, but assumed increased demand for lumber from the Lower 48 States, by considering only the pre-recession rate of growth in domestic lumber consumption, as opposed to the more conservative growth rates used in the baseline model (Daniels et al. 2016). In other words, the PNW Research Station study assesses a range of potential demand scenarios that build upon a baseline model that employs

conservative assumptions regarding the development of future markets. The likelihood that baseline demand will drop below post-recession levels is considered very low.

Observed declines in timber harvest should not supplant the use economic theory and peer-reviewed methodology to project demand for Tongass National Forest timber in an objective and scientific manner. There are many extenuating circumstances, unrelated to market demand for forest products, that impact actual timber harvest including administrative appeals and delays, litigation, agency budget, and other administrative challenges.

COMMENT

MKD-1b: The Proposed Forest Plan and all of the alternatives (including no action) evaluated in the DEIS are based on an inflated estimate that market demand for timber will average 46 MMBF per year for the next fifteen years, regardless of the allocation between old-growth and second-growth. This results in the DEIS overstated the number of jobs supported and the overall economic benefits of logging. The Forest Service should revise this estimate downward and vary projected timber outputs by alternative.

RESPONSE

Concerns that the PNW Research Station demand study overestimates potential timber demand are discussed in response to MKD-1, above.

As discussed in Chapter 2 of the Draft EIS, the Proposed Action and range of alternatives developed for the Draft EIS were designed to maximize or emphasize the percentage of harvest volume coming from young growth as early as possible, while minimizing any potential effects on the old-growth Conservation Strategy and other resources. Alternatives 1 through 5 in the EIS were designed to produce a PTSQ of about 46 MMBF per year during the next 15 years, with old growth making up a decreasing percentage of the total. Old-growth volume would continue to decrease until it reaches about 5 MMBF per year and it would remain at that level, to support limited small timber operators. As more young growth becomes economic to harvest, the PTSQ would be allowed to increase.

In past Forest Plan revisions and amendments, varying demand scenarios were used to develop alternatives, including scenarios that allowed for growth and expansion of the current industry. In this amendment, the purpose and need requires the transition to a predominantly young-growth based industry and the reduction of old-growth harvest. The alternatives evaluated in the EIS differ in their approach to meeting this purpose and need, rather than varying the volume expected to be made available for harvest. Each alternative evaluated in detail in the EIS differs in terms of suitability of lands (i.e., determination made regarding the appropriateness of various lands within a plan area for various uses or activities, based on the desired conditions applicable to those lands) and other plan components (goals; desired conditions; objectives; standards; guidelines) that dictate direction and may apply forest-wide or to specific LUDs. These variations among alternatives affect the ability of each alternative to meet the purpose and need of the proposed amendment, and the speed at which the transition to young-growth could potentially occur.

The Forest Service will continue to evaluate annual market demand using the Morse methodology and may adjust the total volume, as well as the mix of old-growth and young-growth timber, made available for sale on a year-to-year basis, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry.

COMMENT

MKD-1c: The Draft EIS does not discuss current export market information compiled by the PNW Research Station and ignores the substantial weakening of export markets and the competitive disadvantage of Alaska and Pacific Northwest raw log exporters. Recent PNW Research Station press releases indicate that both the value and volume of log exports from Alaska and the West Coast are declining and at a much greater rate than other timber exporting regions.

RESPONSE

The Draft EIS provides an overview of the modeling approach used by the PNW Research Station to estimate market demand for timber (see pp. 3-455 to 3-460). More detailed information regarding the methodology and data sources used for the PNW Research Station study is provided in Daniels et al. (2016). These projections are based on longitudinal trend information available at the time the demand study was completed (summer 2015) and do not include data from the more recent PNW Research Station press releases and publications cited in the comment. The demand projections developed by Daniels et al. are based on long-term trends and represent long-term, planning cycle demand. Short-term fluctuations in demand are represented in the Morse methodology, which informs the amount of timber offered in a year.

COMMENT

MKD-2: The project record indicates that the DEIS inflates the volume of old-growth – 5 MMBF per year – needed to sustain small timber operators. An email exchange between the Regional Economist and the lead author of the PNW Research Station's demand study indicates that the volume used by small operators "is probably somewhere between 1.4 MMBF and 3.0 MMBF." This inflated estimate will result in future levels of old-growth logging that are higher than needed to support small operators.

RESPONSE

Data compiled from publicly available reports posted on the Alaska Region Forest Management and Accomplishment Reports web page indicates that from 2005 through 2014, small operators had an annual average of 11 MMBF of uncut timber under contract, ranging from an annual low of 6 MMBF in 2014 to a high of 17 MMBF in 2008 and 2009 (see the first table below). The same data source indicates that small operators harvested an annual average of 7 MMBF over the same time period, ranging from an annual low of 4 MMBF in 2006 to a high of 11 MMBF in 2011 (see the second table below). These data indicate that the annual estimate of 5 MMBF of old growth volume needed to sustain small timber operators is lower than the annual average volume harvested over the past 10 years. These numbers suggest that based on current and past volumes under contract and harvest levels, 5 MMBF is not an overstatement of the volume likely to be required by small operators.

See: http://www.fs.usda.gov/detail/r10/landmanagement/resourcemanagement/?cid=fsbdev2_038785

Estimated Tongass National Forest Small Sale Volume Cut

Fiscal Year	Current Qty Est (rounded MMBF)	Volume Cut (rounded MMBF)	Remaining Vol (rounded MMBF)
2014	13	7	6
2013	19	10	9
2012	20	9	11
2011	19	9	10
2010	18	10	8
2009	24	7	17
2008	23	6	17
2007	23	7	16
2006	14	5	9
2005	13	5	8
Average	19	7	11

Calendar Year	Current Qty Est (rounded MMBF)	Volume Cut (rounded MMBF)	Remaining Vol (rounded MMBF)
2014	14	6	8
2013	17	9	8
2012	20	10	10
2011	19	11	8
2010	16	9	7
2009	22	7	15
2008	32	6	26
2007	22	6	16
2006	14	4	10
2005	13	5	8
Average	19	7	12

Source: USDA Forest Service 2016[9]

COMMENT

MKD-3: The Proposed Forest Plan explicitly adopts, for the first time, a fixed PTSQ. This new provision must comply with the 2012 planning rule, which requires that a Forest Plan provides for economic sustainability. The EIS must analyze whether the new PTSQ and the associated plan objective (O-TIM-01) comply with the economic sustainability requirement of the 2012 planning rules.

RESPONSE

Timber objectives O-TIM-01 and O-TIM-02 have been revised in the Final EIS. This is discussed further in response to Comment TIM-11. These revisions clarify that O-TIM-01 is not intended to be a fixed target.

COMMENT

[9] USDA Forest Service. 2016. Timber Volume Under Contract, various years. Available online at: http://www.fs.usda.gov/detail/r10/landmanagement/resourcemanagement/?cid=fsbdev2_038785

MKD-4: Each year the Forest Service uses the Morse methodology to estimate the volume of timber it needs to offer for sale to maintain adequate inventory for purchasers. This methodology uses the PNW Research Station demand projections as part of this calculation, which tends to overstate the volume required, and will continue to do so in the future if the latest PNW Research Station projections (Daniels et al. 2016) are used. The Forest Service must monitor demand on an annual basis or develop different estimates that project lower demand than Daniels et al.

RESPONSE

Specific concerns regarding the PNW Research Station demand projections are discussed in response to MKD-1a and elsewhere in this comment response document. As discussed in response to comments regarding the economics of the timber industry (see, for example, ECON-1, -5, -6, and -8), the Forest Service will continue to evaluate annual market demand using the Morse methodology, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry. Revisions to the Morse methodology are outside the scope of this Forest Plan amendment.

COMMENT

MKD-5: The Draft Forest Plan sets a goal of maintaining a three-year supply of timber under contract based on "annual timber consumption (i.e., the amount that is expected to be logged in a given year)." If the annual amount expected to be logged is based on the PNW Research Station forecasts, it will likely be too high, and the over-estimate will then be tripled in an attempt to maintain a three-year supply, causing the Forest Service to waste public resources on the preparation of unnecessary timber sales.

RESPONSE

Specific concerns regarding the PNW Research Station demand projections are discussed in response to MKD-1a and elsewhere in this comment response document. The goal of maintaining a three-year timber supply is to allow flexibility for forest products businesses to plan their operations and to allow flexibility in the timing of selling final products. In order to accomplish this goal, there needs to be more timber under contract than actual timber harvest. Annual projected harvest is based on the Morse Methodology. The 2008 Forest Plan revision used the Morse Methodology consistently as has the annual market demand calculations. This is explained in the Big Thorne FEIS, Appendix A and other project EISs. These sections have been revised, over time, to clarify this concept for the public. The Forest Service will continue to evaluate annual market demand using the Morse methodology, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry. Revisions to the Morse methodology are outside the scope of this Forest Plan amendment.

COMMENT

MKD-6: The Morse methodology used by the Forest Service to estimate annual market demand is based in part on mill capacity, which it defines as "the amount of net sawlog volume that could be utilized by the sawmill, as currently configured, during a standard 250 day per year, two shifts per day annual operating schedule – and, not limited by availability of workforce, raw materials, or market conditions." The Draft EIS shows that utilization of active mill capacity has been significantly lower than this amount in recent years. Viking Lumber, for example, has a listed capacity of 80 MMBF, but has milled one-fifth of this amount.

RESPONSE

The Forest Service will continue to evaluate annual market demand using the Morse methodology, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry. Revisions to the Morse methodology are outside the scope of this Forest Plan amendment. It may also be noted that observed declines in timber harvest and utilization rates do not necessarily equate to a reduction in demand. There are many extenuating circumstances, unrelated to market demand for forest products, that impact actual timber harvest including administrative appeals and delays, litigation, agency budget, and other administrative challenges.

COMMENT

MKD-7: The Draft Forest Plan has raised the "volume-under-contract goal" revising it from 2 to 3 years supply to 3 years supply without explanation or related analysis. The proposed change should be deleted or the Forest Service should explain why the change is necessary.

RESPONSE

Language in the Draft Forest Plan was updated to "(p)rovide about 3 years supply of volume under contract to local mills and then establish NEPA-cleared volume to maintain flexibility and stability in the sale program" (p. 2-5). This objective is identified in the 2008 Forest Plan as "2 to 3 years supply of volume." This objective was revised in response to public concern and comments received during timber harvest project environmental analysis document reviews, which questioned whether the amount should be 2 or 3 years supply – or somewhere in between (2.5 years). In order to make the objective clearer, one number was used instead of the prior range. The higher number (3 years) was selected because it is more representative of our practices and provides more flexibility with a higher volume under contract to mitigate the impact of potential delays in offering timber volume. Factors causing potential delays in offering timber volume include policy changes or injunctions during litigation which preclude either harvesting or offering certain projects. Harvest levels also fluctuate with changing markets and the amount of timber available, and also vary due to mobilization and weather-related impacts. In short, three years of volume under contract is not a change from our current practices and is preferable to help address market fluctuations and other changes in conditions.

COMMENT

MKD-8: The PNW Research Station demand estimates do not comply with the requirements of TTRA because the analysis accounts for round log exports, which were limited from the Tongass in 1990 when TTRA was enacted. It was never the intent of Congress that the mills in Southeast Alaska would have to compete against the round log export market.

RESPONSE

As discussed in the Draft EIS, for the past 25 years, the Forest Service has commissioned the PNW Research Station to prepare a number of long-term projections of demand for Tongass timber over time, including Brooks and Haynes (1990, 1994, 1997) and Brackley et al. (2006a, 2006b). The PNW Research Station has prepared a similar analysis in support of the current proposed amendment of the Forest Plan (Daniels et al. 2016). Using methods adapted from the previous PNW Research Station analyses, Daniels et al. estimate demand for Tongass timber using a materials balance approach based on projected trends in product markets. The analysis projects future demand for timber ("derived demand") based on the overall end-market demand in foreign and domestic markets and the portion of that demand Alaska is likely to fill (based on historic trends).

The 2015 PNW Research Station study identified five primary timber products harvested from Southeast Alaskan forests -- softwood sawlogs, utility logs, softwood lumber, mill residue, and other products – and projected the associated demand by product. The analysis accounts for the demand for unprocessed logs and assumes that logs from the Tongass would continue to be exported. The limited export policy has affected the amount of logs available for local processing in recent years by allowing timber sales that would otherwise have been uneconomic to appraise positively and be made available for purchase. Part of the resulting sale may then be exported while the remaining volume is processed locally. Assuming that this practice would remain in place – by using recent trends to estimate future demand – reflects the current environment within which the Southeast Alaska timber industry operates. Viewed from a modeling perspective, the mills in Southeast Alaska are not competing with the round wood log export market. Timber export policy is discussed further in the Timber Export Policy section of this response to comments document.

COMMENT

MKD-9: The PNW Research Station study (Daniels et al. 2016) overestimates the volume of private timber that will be available for local processing, with volumes projected to increase from existing harvest levels (about 61 MMBF) to about 80 MMBF over the next 15 years. The study also overstates the volumes expected to be offered on state lands and assumes they will be offered on an annual basis. These overestimates result in the NFS volume being reduced to just 46 MMBF per year. Based on this low volume and the Forest Service's record of consistently underperforming on their timber sale volume, purchasers cannot risk investing in their businesses to stay competitive.

RESPONSE

The PNW Research Station long-term timber demand projections (Daniels et al. 2016) are based on economic theory, peer-reviewed methodology, and scientific and objective analyses conducted by timber economists and forest researchers. The PNW Research Station study projected future demand for timber ("derived demand") based on the overall end-market demand in foreign and domestic product markets and the portion of that demand Alaska is likely to fill (based on historic trends). The baseline demand projections developed by the PNW Research Station were developed in three stages: 1) historic estimates of Alaska forest products output by product and destination were gathered and projected from 2015 to 2030; 2) the raw material requirements necessary to support this projected output were estimated by product type; and 3) the timber harvest equivalent was calculated and allocated by owner, including Native Corporation and State lands (Daniels et al. 2016). Based on historic trends, Daniels et al. assumed that Native Corporation harvest would be exported as unprocessed round wood, with none of this timber expected to be available for local processing. .For State harvest, Daniels et al. assumed that 70 percent of State logs would be exported as unprocessed round wood, with the remaining 30 percent processed in Southeast Alaska.

The PNW Research Station study developed projections for State and Native Corporation harvest as part of the baseline and three scenarios constructed as part of their study. State and Native Corporation harvest varied by scenario based on the underlying assumptions. Assuming that 30 percent of State harvest would be available for local processing results in an annual average of 6.2 MMBF (Baseline and Scenario 1) to 7.8 MMBF (Scenario 2) available from 2015 to 2030, equivalent to about 13 percent to 17 percent of the PTSQ. As discussed above, the Forest Service will continue to evaluate annual market demand using the Morse methodology or a similar process and may adjust the total volume, as well as the mix of old-growth and young-growth timber, made available for sale on a year-to-year basis, as needed to meet demand and the Secretary's direction to speed the transition toward a young-growth timber industry.

COMMENT

MKD-10: The PNW Research Station study's (Daniels et al. 2016) Scenario 2 assumes increased demand for wood-based energy products. The economics of wood-based energy products in Southeast Alaska are marginal even with extensive subsidies and Daniels et al.'s projected utility log harvest for this scenario overstates the utility log share of total harvest. Utility logs at most average about 15 percent to 17 percent of total harvest. Timber supply constraints effectively limit wood-based energy to sawmill residuals, most of which are already being effectively used.

RESPONSE

The PNW Research Station's timber demand projections are based on economic theory, peer-reviewed methodology, and scientific and objective analyses conducted by timber economists and research scientists. "Derived demand", as defined by the PNW Research Station scientists, is the volume of national forest harvest needed to meet projected consumption of Alaska forest products, over time, given the harvest levels of other owners and based on assumptions about product markets. In addition to projecting baseline timber demand, scientists also developed three scenarios that represent a range of possible future market conditions. Scenario 2, the "wood energy" scenario, accommodates the US Forest Service's 30 percent conversion goal from distillate fuels to wood-based energy products for Southeast Alaska's residential, commercial, and industrial sectors. Scenario 2 and the other scenarios evaluated in

the demand study represent different futures and are an attempt to project the future based on past observations and potential future conditions that may or may not come to fruition.

COMMENT

MKD-11: The PNW Research Station demand study (Daniels et al. 2016) does not estimate the cost of accessing, transporting, and harvesting young-growth timber, and contains no Alaska-specific estimates of the cost of producing timber from young-growth timber. The absence of this analysis undermines the credibility of the study's estimates of young-growth demand.

RESPONSE

Daniels et al. (2016) is the fifth scientific analysis performed since 1990 to assist forest planners in meeting statutory requirements for estimating planning cycle demand for timber from the Tongass National Forest. "Derived demand", as defined by PNW Research Station scientists, is the volume of national forest harvest needed to meet projected consumption of Alaska forest products, over time, given the harvest levels of other owners and based on assumptions about product markets. The methodology used to develop these estimates is summarized in the Draft EIS and described in detail in the timber demand study (Daniels et al. 2016). This approach to estimating demand is not based on the type of cost data identified in the comment and, as a result, the PNW Research Station demand study did not develop these types of estimates.

The results of the PNW Research Station demand study are used in the Draft EIS to develop the PTSQ and compare the alternatives. As discussed in Chapter 2 of the Draft EIS, the Proposed Action and range of alternatives developed for the Draft EIS were designed to maximize or emphasize the percentage of harvest volume coming from young growth as early as possible, while minimizing any potential effects on the old-growth Conservation Strategy and other resources.

Although not part of the PNW Research Station demand study, the costs of accessing, transporting, and harvesting young-growth timber were estimated as part of the Woodstock modeling analysis prepared in support of the EIS analysis, and are included in the financial analysis of the alternatives. This is explained further in Appendix B to the Final EIS, which has been updated, as have the results of the financial analysis presented in the Final EIS.

COMMENT

MKD-12: The timber demand analysis prepared by the PNW Research Station was rushed and prepared without seeking input from the State of Alaska or the Southeast Alaska timber industry.

RESPONSE

Input was solicited from the State of Alaska and the Southeast Alaska timber industry as part of the timber demand analysis prepared by the PNW Research Station. Multiple meetings were conducted with the State of Alaska and the Southeast Alaska timber industry during the summer and fall of 2014. The following table lists the visits Dr. Jean Daniels, the lead author of the PNW Research Station demand analysis, made to speak with staff from the state and timber industry about the demand study, along with dates and locations, as well as anyone else who attended these meetings. This concern is also addressed in response to Comment P&N-9 in the Purpose and Need section of this response to comments volume.

Trip	*Date*	*Met with:*	*Where*	*Also in attendance:*
Ketchikan, AK, Summer, 2014	June 20, 2014	Owen Graham	Tongass NF SO	Su Alexander
	June 20, 2014	Clarence Clark	AK DNR, White Cliff Building	
Ketchikan, AK, Fall, 2014	September 15, 2014	Jim Tuttle	Sealaska Corp office	Clarence Clark

	September 15, 2014	Paul Slenkamp	Alaska Mental Health Trust, White Cliff Building	Clarence Clark
	September 15, 2014	Eric Nichols	Alcan Ward Cove export yard	Clarence Clark
POW Island, Fall, 2014	September 16, 2014	Ernie Eads	Thuja Plicata Mill	Clarence Clark
	September 16, 2014	Jim Harrison	Western Gold Cedar Mill	Clarence Clark
	September 16, 2014	Hans Kohn	Good Faith Lumber Mill	Clarence Clark

COMMENT

MKD-13: The PNW Research Station demand analysis was prepared because the Forest Service is planning to reduce the supply of old-growth timber in response to the Secretary's Memorandum. This restriction does not reduce demand, it limits supply. Supply is also limited due to the high costs of harvesting federal timber sales that are a result of the Forest Plan standards and guidelines. Daniels et al. (2016) indicate that existing mills are operating well below capacity, but do not explain that this is due to the constrained timber supply, not a lack of demand. Viking managers have, for example, repeatedly told the Forest Service that they would like to purchase more timber sales. Providing sufficient old-growth timber is the best approach to sustaining a viable timber industry and meeting the intent of TTRA's market demand provision.

RESPONSE

The Tongass National Forest has been directed, per the Secretary's Memorandum 1044-009: "To conserve the Tongass National Forest under the principles of the Multiple-Use Sustained- Yield Act of 1960, Tongass Timber Reform Act and other relevant statutes, we must speed the transition away from old-growth timber harvesting and towards a forest industry that utilizes second growth – or young growth – forests. Moreover, we must do this in a way that preserves a viable timber industry that provides jobs and opportunities for residents of Southeast Alaska." This memorandum does not direct the Tongass National Forest to artificially limit timber supply, rather it directed the forest to expedite the transition from old-growth harvest to young-growth harvest while maintaining a viable timber industry.

The PNW Research Station has projected long-term timber demand, in support of forest planning efforts, for over two decades. The most recent report (Daniels et al. 2016) identifies a number of reasons for undertaking a new timber demand analysis. These include "evolving USDA policy limiting old-growth harvesting and encouraging the harvest of younger second-growth forest stands", the recent transfer of some NFS lands to the Sealaska Corporation, "the entry of Tongass sawlogs into international export markets, rising fuel costs, and efforts to promote biomass energy products and technology for space heating and electricity generation" (Daniels et al. 2016, p.1).

The USDA recognizes the importance of maintaining the existing infrastructure and providing old growth timber to "bridge" the transition to young growth and allow a market to develop for these products. The USDA also recognizes it is important to retain the expertise and infrastructure of the existing industry so businesses can re-tool. Since the Forest Service is also governed by the Multiple Use Sustained Yield Act, there are standards and guidelines in place for the protection of other resources. Efforts are made to reduce the costs of timber harvest and provide economic timber sales but costs are higher in Southeast Alaska than other parts of the country due to the high costs of supplies, difficult terrain and high transportation costs.

COMMENT

MKD-14: The PNW Research Station demand study states that the entry of Tongass sawlogs into international export markets invalidates prior demand assumptions. Tongass cedar sawlogs have been sold into international export markets for many decades, as have hemlock and spruce sawlogs on occasion. The current, temporary log export policy does not lower the demand for timber from the Tongass.

RESPONSE

Daniels et al. (2016, p. 1) identify a number of events that they believe "invalidate many of the assumptions for the last timber demand analysis." These include "evolving USDA policy limiting old-growth harvesting and encouraging the harvest of younger second-growth forest stands", the recent transfer of some NFS lands to the Sealaska Corporation, "the entry of Tongass sawlogs into international export markets, rising fuel costs, and efforts to promote biomass energy products and technology for space heating and electricity generation" (Daniels et al. 2016, p.1). In other words, increased log exports is just one of a number of changes from the last demand study. Daniels et al. do not state that increased log exports have reduced demand for timber from the Tongass.

Prior Pacific Northwest Research Station demand studies were conducted when Japan was the primary market for export logs from Alaska and before the Tongass National Forest began exporting to US domestic and other international markets. The relatively recent developments identified by Daniels et al. have changed the competitive position of Alaskan exports compared to Washington and Oregon. Furthermore, overall timber demand depends on markets for sawn wood and exports for softwood logs.

COMMENT

MKD-15: The proposed PTSQ in the Draft EIS and Forest Plan (46 MMBF) does not provide sufficient timber volume to meet the most recent annual market demand estimates prepared by the Forest Service. These estimates developed for FY2014 using the Morse Methodology indicate that annual demand for that FY was 142 MMBF. As a result, the proposed PTSQ fails to meet the requirements of TTRA Section 101 to seek to meet annual demand from the Forest. The Draft EIS does not explain why the new estimates are almost 100 MMBF lower than the 2014 annual estimate.

RESPONSE

Estimated annual demand for FY 2014 was developed using the Morse methodology, which uses information from a number of sources, including the long-term timber demand projections. These projections will be updated as part of the Forest Plan amendment process, which will affect estimated annual demand in future years. The proposed PTSQ is discussed further in the Purpose and Need section of this response to comments document.

COMMENT

MKD-16: The Tongass Timber Reform Act, sec. 101 requires the Forest Service to "seek to meet" timber demand, and, therefore, the use of an unpublished draft of timber demand projection is unacceptable in the Draft EIS. Further, the Draft EIS refers to the same study inconsistently as Daniels (2015), Daniels et al. (2015), and Daniels et al. (in press). In addition, the Draft Forest Plan itself makes no direct mention of the Daniels et al. study.

RESPONSE

The Draft PNW Research Station study was available for public review before the Draft EIS was published. While the associated technical paper was cited as "Draft" or "In press" in the Draft EIS, the projections themselves were finalized prior to completion of the Draft EIS analyses. The report has subsequently been published and is consistently cited throughout the Final EIS as Daniels et al. (2016). The full reference is as follows:

> Daniels, Jean M.; Paruszkiewicz, Michael D.; Alexander, Susan J. 2016**.** Tongass National Forest timber demand: projections for 2015 to 2030. Gen. Tech. Rep. PNW-GTR-934. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 53 p.

The Draft Forest Plan indirectly references the findings of the PNW Research Station demand study in the new Forest-wide timber objectives added as part of Chapter 5. These objectives have been revised in the Final Forest Plan. The Daniels et al. study is not directly referenced in the Draft Forest Plan. Similarly, the demand study conducted in support of the 2008 Forest Plan (Brackley et al. 2006) is not directly referenced in the 2008 Forest Plan.

COMMENT

MKD-17: The current Draft EIS understates market demand and establishes a PTSQ that is the volume the Forest Service wishes to add, rather than what the industry needs to continue operating. An unrealistic assessment of market demand may be considered a fatal flaw for a Forest Plan EIS. "The USFS' inflated assessment of market demand was successfully challenged in Natural Resource Defense Council v. USFS, 421 F.3d 797, 811-12 (9th Cir. 2005)." The same flaw exists for this plan, with market demand deflated to the point of being misleading.

RESPONSE

The market demand estimates used in the Draft EIS are PNW Research Station projections developed by Daniels et al. (2016). These demand projections are based on economic theory, peer-reviewed methodology, and scientific and objective analyses conducted by PNW Research Station scientists. The methodology used to develop these projections is summarized in the Draft EIS and discussed in detail in Daniels et al. (2016). Specific concerns regarding the accuracy of the latest PNW Research Station projections are discussed elsewhere in this comment response document.

It may also be noted that the challenge to the market demand assessment cited in the comment related to an error in interpretation of the 1997 market demand calculations, not an "inflated" or "unrealistic" assessment. As explained by the court in the opinion for Natural Resource Defense Council v. USFS, 421 F.3d 797, 811-12 (9th Cir. 2005):

> "The Forest Service misinterpreted the 1997 Brooks and Haynes market demand projection within the published ROD and EIS. The Forest Service incorrectly thought that the projection numbers refer only to "sawlogs suitable for producing lumber," when they actually refer to "total National Forest harvest, including both net sawlog and utility volume." Because of the Forest Service's error, the ROD and EIS project an average market demand for Tongass timber nearly double that which Brooks and Haynes projected. The projected demand scenarios used by the ROD and EIS are 130 MMBF/year (low), 212 MMBF/year (medium), and 296 MMBF/year (high)."

This was one of the issues analyzed and updated by the Brackley et al. (2006) demand calculations for the 2008 Forest Plan Amendment FEIS, Appendix G.

COMMENT

MKD-18: Explain why the Draft EIS uses 25- and 100-year timeframes for comparison purposes. The lifespan of a Forest Plan is 15 years and Forest Service handbook direction requires that a Forest Plan must show volumes for PWSQ (Projected Wood Sale Quantity) and PTSQ (Projected Timber Sale Quantity) for two decades. Based on this requirement, analysis and comparison of alternatives should be based on a 20-year period. Projecting that a Forest Plan and PTSQ will not change over 25- and 100-year periods is misleading to the public.

RESPONSE

The use of 25- and 100-year frameworks is consistent with past Forest Plan EIS analyses and also allows an evaluation of the long-term implications of the alternatives with respect to the proposed young-growth transition. As modeled, the volumes available under the four action alternatives (Alternatives 2 through 5) would support a transition to young-growth by Year 25. In addition, in many cases, analysis results are presented in the Draft EIS by decade.

Concerns related to the treatment of the PWSQ and PTSQ in the Forest Plan are discussed elsewhere in this comment response document, see for example TIM-5. The Draft EIS does not assume that the PTSQ would remain unchanged following completion of the young-growth transition. As discussed in the

Draft EIS, once the transition occurs (with the share of total harvest comprised of old-growth stabilized at 5 MMBF), the amount of timber offered for sale would be allowed to increase above 46 MMBF as more young growth becomes economic to harvest.

COMMENT

MKD-19: The annual PTSQ of 46 MMBF is based on the baseline projections developed by the PNW Research Station, rather than Scenario 1, which assumes the young-growth transition would occur by 2025, with a subsequent decline in projected demand (see Table 2-1 in the Draft EIS). Using the baseline projection overstates potential demand, and compounds multiple other issues with the PNW Research Station projections.

RESPONSE

The Draft EIS compares the alternatives with three demand scenarios developed from the initial baseline projections. Using the baseline projections to estimate the PTSQ is consistent with this approach. It should also be noted that the annual average difference between the baseline and the Scenario 1 estimates developed by the PNW Research Station is 1.8 MMBF. The use of the baseline model projection is discussed further below in response to MKD-20.

COMMENT

MKD-20: The PNW Research Station demand projections are for a 15-year period. These projections should be for 20 years to allow development of the PWSQ and PTSQ. In addition, the PTSQ established in the Draft Forest Plan (46 MMBF) is less than the derived demand for the three scenarios developed by Daniels et al. (2016). The PTSQ should at least be equal to the largest derived demand volume for the first two decades of the plan.

RESPONSE

The Daniels et al. (2016) study of long-term timber demand projections is based on economic theory, peer-reviewed methodology, and scientific and objective analyses conducted by timber economists and forest researchers. Daniels et al. avoids recommending any one scenario as a “most likely” projection because of the relatively high degree of uncertainty surrounding developments in Southeast Alaska. The baseline model, however, utilizes historical datasets necessary to represent Southeast Alaska timber markets and assumes the timber industry in Southeast Alaska will remain at post-2008 recession levels for the next 15 years. As such, the baseline annual average of 46 MMBF timber demand from the Tongass represents a conservative and rational estimate. In addition, the 46 MMBF projection is not only represented in the baseline model, but it is also represented in all three scenarios at different points in time, and these scenarios represent alternative futures for timber harvest in Southeast Alaska.

It should also be noted that the PNW Research Station projections estimate planning cycle demand. The Forest Service will continue to evaluate annual market demand using the Morse methodology and may adjust the mix of old-growth and young-growth timber made available for sale on a year-to-year basis, as needed to meet demand and the Secretary’s direction to speed the transition toward a young-growth timber industry.

COMMENT

MKD-21: The Draft EIS needs to clearly define the terms “viable timber industry” and “existing industry.” These terms need to be defined for the Forest Service to be able to: a) develop a Forest Plan that “preserves” or “retains” the timber industry, and b) assess positive or negative changes in the timber industry as a result of implementing the transition.

RESPONSE

The term “existing industry” refers to the industry as it currently exists, as described in the Draft EIS (pp. 3-448 through 3-454). The phrase “viable timber industry” as used in the Draft EIS refers to a timber industry that meets a dictionary definition of “viable”: i.e., Viable (adj) -- Capable of working successfully; feasible (Oxford Dictionary). The form that this industry will take is expected to evolve over time as the transition towards predominantly young-growth harvest occurs. In the short-run, in the absence of sufficient young-growth volume to meet average annual demand, the Forest Service will offer a mix of

old-growth and young-growth volume. Over time, the old-growth share will decrease as more young-growth timber becomes available to harvest. This is expected to be a period of transition that will allow the opportunity for existing operations to retool and/or new operations to develop in response to changing supply conditions. Small operators will continue to have the opportunity to process old-growth timber with an annual average of 5 MMBF of old-growth volume expected to be made available through and following the young-growth transition.

COMMENT

MKD-22: The Forest Plan amendment is based on a circular argument: the alternatives are all designed to meet a PTSQ that has clearly been limited in response to the Secretary's policy decision to accelerate a transition to young-growth harvesting. The Forest Service should adopt a No Action alternative that allows annual old-growth harvests of up to 167 MMBF in accordance with the 2008 Forest Plan, while also allowing the Forest Service to offer more young-growth sales to help begin a young-growth transition.

RESPONSE

As discussed in response to MKD-13 (above), the PNW Research Station has projected long-term timber demand, in support of forest planning efforts, for over two decades. The most recent report (Daniels et al., 2016), which is the fifth such analysis performed since 1990, identifies a number of reasons for undertaking a new timber demand analysis. These include "evolving USDA policy limiting old-growth harvesting and encouraging the harvest of younger second-growth forest stands", the recent transfer of some NFS lands to the Sealaska Corporation, "the entry of Tongass sawlogs into international export markets, rising fuel costs, and efforts to promote biomass energy products and technology for space heating and electricity generation" (Daniels et al. 2016, p.1).

The projections developed by Daniels et al. are based on economic theory, peer-reviewed methodology, and scientific and objective analyses, and use a "derived demand" approach. The analysis projects future demand for timber ("derived demand") based on the overall end-market demand in foreign and domestic markets and the portion of that demand Alaska is likely to fill (based on historic trends). Baseline demand projections Tongass timber were developed in three stages: 1) historic estimates of Alaska forest products output by product and destination were gathered and projected from 2015 to 2030; 2) the raw material requirements necessary to support this projected output were estimated by product type; and 3) the timber harvest equivalent was calculated and allocated by owner (Daniels et al. 2016). These baseline projections were used in the Draft EIS to develop the PTSQ. As this brief summary suggests, the baseline estimates developed by Daniels et al. were not constrained or otherwise affected by the Secretary's policy decision to speed up the transition to young-growth harvesting. The methodology employed to develop these projections is discussed in more detail in Daniels et al. (2016).

As discussed in Chapter 2 of the Draft EIS, the No Action Alternative represents current management direction (2008 Forest Plan) and includes the application of the Roadless Area Conservation Rule (2001 Roadless Rule). Under this alternative, timber harvest would follow the existing timber sale program adaptive management strategy in all phases outside of inventoried roadless areas. Timber management would be restricted to the development LUDs and no commercial harvest would be allowed in beach and estuary fringe or RMAs. In other words, the No Action alternative continues to follow 2008 Forest Plan management direction, but the upper harvest limit has been adjusted downward from an allowable sale quantity of 167 MMBF to a PTSQ of 46 MMBF in recognition of changed market and other conditions, as summarized above in the first paragraph of this response.

COMMENT

MKD-23: The Draft EIS fails to describe the uncertainties and risks associated with its Preferred Alternative. The Draft EIS fails to identify the share of projected harvest that would be exported as logs versus processed locally, and also fails to identify the final destination of these logs and wood products. The Draft EIS also fails to describe the uncertainties and risks involved in its demand projections, specifically the potential consequences should projected demand fail to materialize. This does a disservice to business owners and others who may make decisions based on these projections.

RESPONSE

As discussed in the Timber Export Policy section of this response to comments document, the Draft EIS makes several assumptions regarding the limited export policy, including the following:

- The financial analysis prepared for the Draft EIS (which has been updated for the Final EIS) assumed that all western redcedar would be processed domestically and that all Alaska yellow-cedar would be sent to markets outside of Alaska, with Western hemlock and Sitka spruce volumes and other species assumed for the purpose of this analysis to be divided equally between domestic production and export in accordance with the current limited export shipment policy (Draft EIS, p. 3-481).
- The timber-related employment and income estimates presented in Table 3.22-18 in the Draft EIS were based on a range, from maximum possible shipment out of state (export of all Alaska yellow cedar plus hemlock and Sitka spruce export equal to 50 percent of total sale net sawlog volume), to no shipment of hemlock and Sitka spruce and export of 100 percent of Alaska yellow cedar. (Draft EIS, p. 3-484).

The assumptions used to develop the PNW Research Station demand projections are discussed in detail in Daniels et al. (2016). The demand study looked at export figures over the last 5 years and used these numbers to estimate softwood sawlog exports. These trend-based projections therefore reflect export trends in light of the export policy as well as the case-by-case export allowances beyond that programmatic approval.

The 2015 PNW Research Station study identified five primary timber products harvested from Southeast Alaskan forests: softwood sawlogs, utility logs, softwood lumber, mill residue, and other products. The projected allocation of Tongass timber by market is shown in Table 3.22-8 of the Draft EIS (pp. 3-456 to 3-457) and discussed in detail in Daniels et al. (2016).

The Draft EIS discusses factors affecting the projected demand and other factors that affect the timber sale program in the Timber section of Chapter 3 (pp. 3-310 to 3-311). Daniels et al. (2016, p. 45) provide the following discussion regarding sensitivity:

> "Our approach to incorporating and displaying uncertainty has two components. The first is the design and analysis of the three management scenarios. The second is a sensitivity analysis in which we examined the effects of changes in individual elements of the projections. The sensitivity analysis showed model results to be most sensitive to changes in Pacific Rim log export markets. This highlights the importance of competitiveness relative to producers in the Pacific Northwest and other global log suppliers. Our model showed that the young-growth transition is most likely to affect lumber production; maintaining Pacific Rim log export markets in the face of changing raw material quality and the high costs of harvesting and transporting material are central issues facing the competitiveness of the Alaska forest sector."

A reference to this discussion has been added to the section that summarizes the PNW Research Station demand projections in the Final EIS.

COMMENT

MKD-24: The PNW Research Station projections are not based on price, and therefore, are not really demand projections at all. Instead of considering price, the demand study assumes that the quantity produced will be determined by other factors that are subject to the Forest Service's decision-making authority. As a result, the "Forest Service is more or less saying that the demand for TNF timber will be however much it wants to log, based on its interpretation of 'multiple policies and objectives."

RESPONSE

The PNW Research Station demand projections are not based on price as explained in Daniels et al. (2016, pp. 21-22):

> Projected harvest from the Tongass National Forest is calculated as the volume of timber required to meet the shortfall between projected demand and harvest from other ownerships, primarily Native Corporation and State of Alaska lands. In other words, derived demand for Tongass timber is computed as a residual—the quantity of national forest timber necessary to balance the market. … Historical trends and assumptions about the share of harvest by other ownerships were used to project the share of future harvest to be met by the Tongass. The method is based on quantity, rather than price, because timber harvests from public lands are generally planned based on multiple policies and objectives, rather than on prices alone.

The methodology and data used to develop the PNW Research Station projections is further described in detail in Daniels et al. (2016). As stated in the above quote and explained in Daniels et al. (2016) and the Draft EIS, the demand estimates are based on historical trends and assumptions about the share of harvest, and are influenced by factors outside the Forest Service's decision-making authority.

The Forest Service disagrees with the characterization in the comment that the "Forest Service is more or less saying that the demand for TNF timber will be however much it wants to log, based on its interpretation of 'multiple policies and objectives.'" The demand projections prepared by Daniels et al. and reported in the Draft EIS are based on economic theory, peer-reviewed methodology, and scientific and objective analyses conducted by PNW Research Station scientists.

COMMENT

MKD-25: The EIS should account for the impact of deficit timber sales and log export restrictions on the expected demand for wood products from young-growth logs and describe how these factors would cause the socioeconomic impacts of the alternatives to differ from those described in the Draft EIS.

RESPONSE

The demand projections developed in support of this EIS are discussed in the Draft and Final EIS documents and Daniels et al. (2016). Concerns regarding these projections are discussed elsewhere in this comment response document, see, for example, the response to MKD-1a. Daniels et al.'s (2016) approach to uncertainty is discussed in response to MKD-23.

The Draft EIS presents projected levels of annual employment and income by alternative in Table 3.22-18. These estimates are based on the maximum annual average harvest that could occur over the first decade following implementation (Years 1 to 10). All five alternatives are based on an annual PTSQ of 46 MMBF, with the proportion of the total that is made up of young growth increasing over time, and the share made up of old growth decreasing. The estimates presented in Table 3.22-18 are based on a range that accounts for variations in export restrictions and behavior. The estimates range from maximum possible shipment out of state (export of all Alaska yellow cedar plus hemlock and Sitka spruce export equal to 50 percent of total sale net sawlog volume), to no shipment of hemlock and Sitka spruce and export of 100 percent of Alaska yellow cedar.

Further, the Draft EIS analysis recognizes that the numbers presented in Table 3.22-18 are estimates based on average jobs per MMBF ratios that were developed using harvest and employment data from 2007 to 2010. As discussed in the Draft EIS, actual employment and income in Southeast Alaska will depend on choices made by purchasers, and these choices may change as markets and prices shift. Actual employment and income will also vary as timber offerings are packaged to include some or all of the units, and individual sales targeted for different sized operators are developed.

COMMENT

MKD-26: The Forest Service must discard the Draft EIS and prepare a revised Draft EIS based on a new range of demand projections that employ a different methodology to those prepared by the PNW Research Station and more explicitly incorporate risk and uncertainty. The revised Draft EIS must describe risk and uncertainties and develop alternatives that explicitly address them by responding to a new range of demand projections, rather than the PTSQ used in the current DEIS.

RESPONSE

Specific concerns regarding the PNW Research Station demand projections are discussed in response to MKD-1a and elsewhere in this comment response document. The Forest Service disagrees with the assertions that the Draft EIS must be discarded and that a different methodology must be employed to estimate market demand. Concerns regarding the use of a range of demand projections and potentially varying levels of demand by alternative are discussed in response to MKD-1b.

COMMENT

MKD-27: The baseline projections developed by the PNW Research Station and presented in the Draft EIS Table 3.22-9 indicate that Native Corporation and State lands will account for a large share of timber harvest in Southeast Alaska over the next 15 years. The Draft EIS and supporting analyses do not consider whether this projected supply of non-federal timber would reduce the demand for federal timber or meet the Forest Service's objective to meet timber demand and support logging and export jobs.

RESPONSE

As discussed in the FEIS and in response to Comment MKD-1a (above), the projections developed by the PNW Research Station (Daniels et al. 2016) are based on "derived demand." "Derived demand" in PNW Research Station studies is defined as the volume of national forest harvest needed to meet projected consumption of Alaska forest products, over time, given the harvest levels of other owners and based on assumptions about product markets. Demand for Tongass National Forest timber is estimated using a materials balance approach based on forecasted trends in product markets. Projected harvest from the Tongass National Forest is calculated as the volume of timber required to meet the shortfall between projected demand and harvest from other ownerships, primarily Native Corporation and State of Alaska lands. In other words, derived demand for Tongass National Forest timber is computed as the residual – the quantity of national forest timber required to balance the market – and the projected supply of non-federal timber is part of the analysis used to determine the demand for federal timber.

Timber harvest on Native Corporation and State lands would support logging and export-related transportation jobs over the planning period, and in the case of State lands may also support mill jobs. These potential jobs would be in addition to those identified in Table 3.22-18 in the Draft EIS. The jobs presented in Table 3.22-18 are limited to those that would be supported by federal harvest only. Non-federal harvest would help support a viable timber industry by providing logging and export-related transportation employment, but would not supply sufficient old-growth "bridge timber" to allow the local saw mill industry to re-tool for processing young-growth.

Timber Export Policy (TEXP)

COMMENT

TEXP-1: The Draft EIS fails to consider alternatives in which the limited export policy is not continued unchanged and indefinitely, premising its analysis on the "assum[ption]" that "Western hemlock and Sitka spruce volumes . . . [will] be divided equally between domestic production and export in accordance with the current limited export shipment policy." This assumption – that the limited export policy will continue unchanged in its current form – has a strong effect on the projected timber sale quantity. To comply with NEPA and meet the project purpose and need, the EIS must evaluate alternatives that do not involve continuation of the limited export policy in its current form.

RESPONSE

Initially established in 2007, the Limited Export Policy is intended to boost appraised timber values, provide economic sale opportunities for purchasers, and provide additional processing options for purchasers. As discussed in the Draft EIS (pp. 3-453 to 3-454), the policy has continued since 2007 with modifications that have provided additional opportunities for purchasers. The policy modifies how timber sales are appraised and allowed timber purchasers options on shipping certain small diameter logs from national forest timber sales to outside Alaska. Designed to allow flexibility for timber purchasers, the limited export policy is not something mandated by the US Forest Service on a timber purchaser or automatically or immediately applied to all timber sales. Rather, the policy is applied by request of the timber purchaser after the contract offering is awarded or any time thereafter. Further, the policy is subject to review and modification on an annual basis.

The text from the Draft EIS cited in the above comment pertains to the financial analysis developed as part of the Woodstock modeling process. The financial analysis presented in the Draft EIS has been revised for the Final EIS and continues to assume for the purposes of analysis that the current limited export shipment policy remains in place. A detailed discussion of the methodology and assumptions used to develop this analysis is presented in Appendix B to the Final EIS.

The methodology employed to develop the PNW Research Station's timber demand estimates is summarized in the *Economic and Social Environment* section of the Draft EIS and described in detail in the PNW Research Station demand study (Daniels et al. 2016). The demand study looked at export figures over the last 5 years (during which the limited export policy has been in place) and used these numbers to estimate softwood sawlog exports.

The employment and income analysis in the Draft EIS assumed a range from maximum possible shipment out of state (export of all Alaska yellow cedar plus hemlock and Sitka spruce export equal to 50 percent of total sale net sawlog volume), to no shipment of hemlock and Sitka spruce and export of 100 percent of Alaska yellow cedar (see Table 3.22-18 in the Draft EIS). The analysis in the Final EIS also presents employment and income estimates for this range.

The assumptions used with respect to the limited export policy for the financial and employment and income analyses are appropriate for this programmatic analysis. Financial efficiency analyses will be conducted as part of the project-specific environmental analysis that will be prepared as part of future timber sale projects. These analyses will take into account the limited export policy and/or other potential restrictions on export or production in place at that time. Project-specific analyses will also consider the employment and income implications of the export restrictions in place or expected to be in place at that time. The Limited Export Policy is discussed further in Appendix H.

COMMENT

TEXP-2: The Draft EIS does not analyze the full extent or impact of the export policy or how it increases the environmental impacts of federal logging. It states that the Forest Service allows the export of up to 50% of the western hemlock and spruce sawlog volume, and notes that Alcan must sell logs that cannot be exported to a processing facility in the state. Actual data show the Forest Service routinely waives these requirements, and allows Viking and Alcan to ship increasing proportions of timber out of the region as unprocessed logs. As a result, the EIS

should disclose that exports often exceed the prescribed limits and consider the additional implications for local employment.

RESPONSE

The timber industry employment and income estimates presented by alternative in Table 3.22-18 are based on a range, from a maximum possible shipment out of state (export of all Alaska yellow cedar plus hemlock and Sitka spruce export equal to 50 percent of total sale net sawlog volume), to no shipment of hemlock and Sitka spruce and export of 100 percent of Alaska yellow cedar. As noted in the comment and explained in the *Limited Export Policy* subsection of the Draft EIS, the Forest Service has allowed timber purchasers to exceed the maximum possible shipment on a case-by-case basis; and this could potentially happen again in the future. However, for the purposes of this programmatic analysis, it is reasonable to evaluate the upper limit as prescribed by the current version of the Limited Export Policy. If purchasers were allowed on a case-by-case basis to export a larger share of a particular sale in unprocessed form, there would be a commensurate reduction in sawmilling jobs and an increase in transportation-related jobs. A note explaining this possibility has been added to the Environmental Consequences part of the *Economic and Social Environment* section in the Final EIS.

As noted in response to TEXP-1, financial efficiency analyses that will compare the export policy in place at the time and domestic processing will be conducted as part of the project-specific environmental analysis prepared as part of future timber sale projects. Project-specific analyses will also consider the employment and income impacts of the current timber export policy. The Limited Export Policy is discussed further in Appendix H.

COMMENT

TEXP-3: The young-growth transition must end the practice of allowing the export of taxpayer-subsidized Tongass timber to compete with logs sold by private landowners on the export market.

RESPONSE

As discussed in response to TEXP-1, a limited shipment policy was instituted on the Tongass National Forest during 2007. The policy modified how timber sales are appraised and allowed timber purchasers options on shipping certain small diameter logs from national forest timber sales to outside Alaska. This policy is subject to review and modification on an annual basis.

The Forest Plan amendment is designed to analyze the feasibility of shifting from an old-growth forest management regime towards young growth management. How rapidly and effectively this is accomplished depends on local support from Alaska markets for young-growth forest products. The ability to export some timber beyond Alaska may serve as a strategic option that can be used to help maintain workforce skills, industry expertise, and the physical infrastructure needed to develop a future young-growth industry. The limited shipment policy will continue to be subject to review and modification on an annual basis, as noted above. The Limited Export Policy is discussed further in Appendix H.

COMMENT

TEXP-4: The Draft EIS does not evaluate the costs and benefits of the Limited Export Policy at all ecological, social, and economic scales.

RESPONSE

As discussed in response to TEXP-1, a limited shipment policy was instituted on the Tongass National Forest during 2007. The policy modified how timber sales are appraised and allowed timber purchasers options on shipping certain small diameter logs from national forest timber sales to outside Alaska. The limited shipment policy will continue to be subject to review and modification on an annual basis, as noted above. Changes to this policy are outside the scope of this Forest Plan EIS.

As noted in response to TEXP-1, financial efficiency analyses will be conducted as part of the project-specific environmental analysis that will prepared as part of future timber sale projects. These analyses will take into account the limited export policy and/or other potential restrictions on export or production in place at that time. Project-specific analyses will also consider the employment and income implications of

the export restrictions in place or expected to be in place at that time. The Limited Export Policy is discussed further in Appendix H.

Recreation and Tourism (R&T)

COMMENT

R&T-1: Tourism management is an important part of the region's economy and integral to the Purpose and Need and to addressing the Secretary's direction to make Forest management more ecologically, socially and economically sustainable and to consider diverse economies. The Forest Service should measure the jobs and economic contributions that recreation programs support in Southeast Alaskan communities. Tourism associations and businesses must be engaged as partners early in planning processes to build buy-in for projects. While tourism provides thousands of jobs and significant economic opportunity, the US Forest Service continues to decrease budgets for recreation, heritage, and wilderness programs.

RESPONSE

The Draft EIS acknowledges the economic importance of tourism to the region as a whole, as well as at the borough and community level (see the *Economic and Social Environment* section of the Draft EIS). The amended Forest Plan responds to the July 2013 memo from the Secretary of Agriculture directing the Tongass National Forest to transition its forest management program to be more ecologically, socially, and economically sustainable, while also being responsive to comments from the Five-Year Review of the Forest Plan. This is explained further in the Purpose and Need section of the Draft EIS, starting at page 1-4. See also the response to P&N-7.

The US Forest Service recognizes the importance of supporting regional economic diversification – and the relationship between public land management and creating economic opportunities for Southeast communities. The draft *Tongass National Forest Plan Monitoring Program* directs the Forest Service to assess whether the forest plan is providing "a diversity of opportunities for resource uses that contribute to local and regional economies of Southeast Alaska." The draft monitoring program further recommends studying employment trends for three primary industries – forest products, recreation and tourism, and seafood – on a biennial basis. This draft monitoring objective acknowledges the importance of the forest plan supporting a wide range of natural-resource employment opportunities across Southeast Alaska.

Recreation and tourism management direction continues to be provided in the Forest-wide Standards and Guidelines for Recreation and Tourism (Forest Plan, Chapter 4), as well as the management prescriptions for each LUD (Forest Plan, Chapter 3). The Forest Service will continue to work with the timber industry and other government agencies, as indicated in the Forest Plan (see, for example, the Forest-wide Standards and Guidelines for Recreation and Tourism, including those that specifically address Tourism [p. 4-41]).

Many factors affect the availability of public sector funds for multiple program areas. Consideration of funding strategies and resource allocation is outside the scope of this forest plan amendment and EIS.

COMMENT

R&T-2: The DEIS inadequately considers saturation at recreation sites, impacts to recreation opportunities and places and the benefits from expanding recreation. The Plan's suggestion that permit access be restricted in recreation places where demand exceeds supply is troubling as tourism businesses seek sustainable ways to grow. The Forest Service should consider prioritizing areas for recreation to address demand for recreation places exceeding supply, and recognize the significant undeveloped potential for tourism opportunities in small communities.

RESPONSE

The DIES acknowledged that demand appears to exceed supply in some recreation places, including bear-viewing areas and helicopter use in the immediate vicinity of urban areas (p. 3-347) and that management practices for specific areas will continue to be evaluated on a project-by-project basis and in accordance with the applicable Forest Plan standards and guidelines under all alternatives. Limiting access via permit is provided as an example of the type of management practice that would be evaluated in this way. The text is not intended to imply that the Forest Service plans to limit permit access as part of

this Forest Plan amendment. Forest Plan recreation and tourism management direction will continue to be provided in the Forest-wide Standards and Guidelines for Recreation and Tourism (Forest Plan, Chapter 4), as well as the management prescriptions for each LUD (Forest Plan, Chapter 3).

Expansion of recreation places is outside of the scope of the narrow scope of this amendment; however, the proposed changes do not preclude the consideration of recreation expansion in the future.

COMMENT

R&T-3: The US Forest Service has been directed, by Secretary Vilsack, to support communities and jobs while also making management more ecologically, socially, and economically sustainable. Tongass National Forest habitat supports wild salmon and the region supports a robust visitor industry. Despite a growing visitor industry, the US Forest Service continues to cut recreation program budgets that support the tourism industry, which is a socially, economically, and ecologically sustainable industry.

RESPONSE

In a memorandum dated July 2, 2013, USDA Secretary Tom Vilsack directed the US Forest Service to expedite the transition from old-growth to young-growth timber harvest while maintaining a viable timber industry that provides jobs and opportunities for Southeast Alaska residents. Secretarial Memorandum 1044-99, *Addressing Sustainable Forestry in Southeast Alaska*, affirms the USDA's intent and priority to transition the Tongass National Forest to a more ecologically, socially, and economically sustainable forest management, over the next 10 to 15 years, while maintaining a viable timber industry. The Draft EIS, as prepared by the US Forest Service, describes and analyzes proposed changes to the forest plan to accomplish the transition to young-growth management as provided by Secretarial Memorandum 1044-99. While the memorandum encouraged a multifaceted approach to transitioning the Tongass National Forest, the primary focus is on transitioning the timber harvest program from predominantly old-growth to young-growth timber harvest while maintaining the timber industry.

As noted in response to R&T-1, the US Forest Service recognizes the importance of supporting regional economic diversification – and the relationship between public land management and creating economic opportunities for Southeast communities. The draft *Tongass National Forest Plan Monitoring Program* directs the Forest Service to assess whether the forest plan is providing "a diversity of opportunities for resource uses that contribute to local and regional economies of Southeast Alaska." The draft monitoring program further recommends studying employment trends for three primary industries – forest products, recreation and tourism, and seafood – on a biennial basis. This draft monitoring objective acknowledges the importance of the forest plan supporting a wide range of natural-resource employment opportunities across Southeast Alaska.

Many factors affect the availability of public sector funds for multiple program areas. Consideration of funding strategies and resource allocation is outside the scope of forest plan amendment.

COMMENT

R&T-4: Recreation has long been subsidized by the timber industry through the construction of roads, docks, and other infrastructure. The Forest Service should identify the cost of providing recreation opportunities on the Tongass and use this information to assess recreation user fees in the form of charges per person for facility maintenance.

RESPONSE

The Multiple Use - Sustained Yield Act of 1960 (or MUSYA) (Public Law 86-517) authorizes and directs the Secretary of Agriculture to develop and administer the renewable resources of timber, range, water, recreation and wildlife on the national forests for multiple use and sustained yield of the products and services. Roads and other infrastructure developed as part of the Forest Service's timber program are used for multiple uses including recreation and tourism.

The Forest Plan and Draft EIS do not identify the costs of administering recreation or other programs. This information is, however, readily available to the public in the annual State of the Tongass National Forest report prepared by the Forest Service. The most recent version available online is for Fiscal Year (FY) 2013 (USDA Forest 2014). More recent information is available upon request. In FY 2013, the total budget for the Tongass National Forest was $64.1 million, including: $6.8 million (11 percent) allocated to Recreation, Heritage, and Wilderness Management; $11.4 million (18 percent) allocated to Forest Management; and $12.5 million (20 percent) allocated to Capital Improvements, Infrastructure Maintenance, and Trail Building and Maintenance.

Recreation Fees (Outfitter/Guides & Collection Support, Recreation Sites & Collection Support, and National Pass Sales & Collection Support) accounted for 61 percent ($3.2 million) of the total revenues received by the Tongass National Forest, with Recreation Service Receipts accounting for an additional 2 percent ($0.1 million). Changes to existing user recreation fee structures are outside the scope of the proposed Forest Plan amendment.

COMMENT

R&T-5: How much is spent annually on personnel required to administer recreation on the Tongass National Forest? How much is spent maintaining roads and other infrastructure for recreation? How much of the existing NFS road system is unsupported by timber or recreation maintenance funds and expected to be decommissioned? The Forest Plan should require recreation users to pay for road maintenance in areas that are not presently being harvested. The Forest Plan should address "more systematic timber harvest" that will generate a steady stream of funds to maintain the existing road system and allow for expansion for future young growth harvest.

RESPONSE

As noted in response to Comment R&T-4, the state of the Tongass National Forest finances is reported each fiscal year and readily available to the public in the annual State of the Tongass National Forest report prepared by the Forest Service. The most recent version of this report available online is for FY 2013 (USDA Forest 2014). More recent information is available upon request. In FY 2013, the total budget for the Tongass National Forest was $64.1 million, including: $6.8 million (11 percent) allocated to Recreation, Heritage, and Wilderness Management; $11.4 million (18 percent) allocated to Forest Management; and $12.5 million (20 percent) allocated to Capital Improvements, Infrastructure Maintenance, and Trail Building and Maintenance. Information related to road maintenance and proposed decommissioning on the Tongass National Forest is available in the Access Travel Management Plans prepared for each Ranger District. These plans are available at the District offices.

As noted in response to Comment R&T-4, changes to existing recreation fee structures are outside the scope of the proposed Forest Plan amendment. In general, Congress appropriates funding for federal agencies and specifies how they may spend it. For the most part, increasing allowable harvest levels in the short-term would not necessarily generate additional funds for road maintenance. Increasing allowable harvest levels would also not be consistent with the Secretary's Memorandum 1044-009, which directs the Tongass National Forest to transition away from old-growth timber harvesting and towards a forest industry that utilizes second growth – or young growth – forests.

COMMENT

REC-5. Suggestions for specific recreation areas and trails.

RESPONSE

Modification or creation of specific recreation areas, trails, and related facilities is outside of the scope of this focused plan amendment. These types of changes are generally best determined at the local planning unit.

Wild and Scenic Rivers (WSR)

COMMENT

WSR-1: There are currently no federal Wild and Scenic River designation in the Tongass and yet the Forest Service Management Plan specifies LUDS to protect these characteristic of 32 rivers that were previously recommended by the Forest Service for inclusion on this list. We do not support continued protection of these rivers under the current Wild, Scenic and Recreational LUD designations.

RESPONSE:

Changes to the Wild, Scenic and Recreational River LUDs is outside the narrow scope of this amendment.

Scenery (SCEN)

COMMENT

SCEN-1: The Forest Service should cease planning on components with lowered scenic integrity objectives.

We strongly object to the proposal to reduce scenic integrity objectives in Alternatives 2, 3, and 5. The NFMA directs that the forest planning process include a review of the esthetic impacts of clearcutting, and ensure that clearcuts do not conflict with esthetic resources or recreation. [16 U.S.C. § 1604(g)(3)(F)]. NEPA's policy purposes similarly include a goal of assuring "esthetically .. pleasing surroundings." [42 U.S.C. § 4331(b)(4)]. The proposed LRMP would create a patchwork of 10 acre clearcuts in the beach fringe and allow removal of up to 35% of a stand. [LRMP at 5-8]. The result would be a visual landscape that "appears heavily altered." [DEIS at 3-352].

The beach fringe clearcuts do not meet NFMA's standards. The DEIS recognizes that "Southeast Alaska possesses a remarkable and unique combination of features" that attract visitors and that "[m]ost visitors who travel long distances to see Alaska expect to find it in a wild and "unspoiled state." [FEIS at 3-321]. It further explains that:

Demand for scenic quality can best be represented by the increase in tourist related travel to the Tongass, as well as a heightened awareness and sensitivity to scenic resource values. These facts result in a strong indirect connection between scenic resource values and the economy of southeast Alaska. For example, Southeast Alaska's Inside Passage is advertised by the Division of Tourism, cruise ship operators, and the Southeast Alaska Tourism Council. Their marketing strategy focuses on the scenery of the Tongass National Forest as a major attraction. The visitors to Southeast Alaska would therefore, arrive with expectations and an image of the environment and scenery awaiting them. If current trends continue, demand for viewing scenic landscapes will increase. [Id. at 3-354].

Further, "[t]he ability to market Alaska tourism is dependent on meeting customer expectations of seeing and experiencing vast, untamed land and its wildlife." [FEIS]. Given these findings, it is arbitrary to degrade these valuable scenic landscapes in order to remove low value timber that can be obtained elsewhere. The discussion in the DEIS is not adequate to disclose the effects of this major change. It carries over the analysis from the 2008 TLMP FEIS and changes the numbers and the alternatives and uses the exact same locations as points of reference. It does not link the reduced scenery with areas identified as Visual Priority Routes – a process that took extensive professional work. If the Forest Service continues to proceed with this change, we believe that Tongass National Forest landscape architects should prepare the analysis and a resource report. A distant contractor punching in numbers into a previous analysis does not show the public the true visual impacts.

We would prefer, however, that the Forest Service eliminate this component of the LRMP. The proposed LRMP's scenery goal has two parts. It first provides that the Forest Service is to "[P]rovide Forest visitors with visually appealing scenery, with emphasis on areas seen from the Alaska Marine Highway, tour ship and small boat routes, state highways, major Forest roads, and population recreation places." [LRMP at 2-4]. But then, it provides that the Forest Service should "[r]ecognize that there will be areas where these landscapes are altered by management activities, particularly young-growth timber harvest, and the activity may visually dominate the characteristic landscape." [Id.]. We recommend that you delete this second sentence, and the entire Beach Fringe component of the Proposed Plan.[LRMP at 5-8].

The Beach Fringe logging component is also inconsistent with the proposed LRMP goal for recreation to "[p]rovide a range of recreation opportunities consistent with public demand, emphasizing locally popular recreation places and those important to the tourism industry." [LRMP at 2-4]. The DEIS describes recreation generally, and recognizes that it largely involves marine transportation to bays and along water ways. [DEIS at 3-326-335]. It describes generally some activities that have a low tolerance for other groups, or incompatible activities occurring in close proximity. [Id.] But it never consider the extent to which logging in particular is an incompatible activity that may discourage not only shoreline recreation, but even one of the most critical pieces of the tourism business – the returning customer.

RESPONSE

The alternatives show a range of SIOs for analysis. This range was developed in order that a range of young-growth harvests could be evaluated, especially during the early years with the idea that lower SIOs could help speed up the transition. Any young growth harvest will still require a NEPA analysis at the project level, so impacts to scenery will still be analyzed and disclosed on a project-by-project basis. Public involvement will also be a part of any future project.

Any clearcuts implemented in the suitable land base, including beach fringe, would meet NFMA requirements.

The analysis is linked to the analysis conducted for the 2008 TLMP FEIS so the reader can compare and contrast the visual effects represented in the 2016 alternatives with the visual effects of the 2008 alternatives. This consistency allows the reader to understand how management is changing over time. The analysis does involve all the VPRs on the Forest; Distance Zones and SIOs are both related to VPRs. This is a programmatic EIS; individual VPRs will be analyzed when projects are proposed in project-level NEPA analyses.

The Tongass Landscape Architects recommended the change to the Scenery goal (referenced as LRMP 2-4) by adding “particularly young-growth timber harvest” to reflect the emphasis that has been given to young-growth harvest by Leadership.

COMMENT

SCEN-2. Scenic Integrity Objectives are prejudicial and inconsistent with many local values going back generations.

RESPONSE

Changes to the definitions of scenic integrity objectives, are outside of the narrow scope of this Forest Plan amendment. In this amendment, changes are made only to where SIOs are applied, reducing the level of scenic integrity in areas of renewable energy and young growth harvest to Low and Very Low.

Scenic integrity terminology (High, Moderate, etc.) is not prejudicial, and refers to the level of the integrity, or intactness, of the landscape. It does not refer to a priority or value of the scenery. Scenic Integrity levels are defined within Agricultural Handbook Number 701, “Landscape Aesthetics: A Handbook for Scenery Management”, which is required to be used on all U.S. Forest Service lands and is not specific to the Tongass National Forest. Constituent analysis is a part of the Scenery Management system, with constituents not only being the local population of an area, but the entire American public.

COMMENT

SCENE-3. Suggestions for changes to Visual Priority Routes in Appendix F.

RESPONSE

Changes to Visual Priority Routes is outside the scope of this focused plan amendment.

Roadless Areas (RDLS)

COMMENT

RDLS-1: Forest Service Should Change the Amendment's Appendix A to Permanently Exclude Roadless Areas from Lands Suitable for Timber Production.

It appears that the Draft Forest Plan is intended to keep Inventoried Roadless Areas off limits to logging in its own right, regardless of the fate of the Roadless Area Conservation Rule in two pending court actions or in any future amendments to or litigation over that rule. Commenters appreciate this important amendment and strongly urge the Forest Service to adopt a final plan amendment that protects roadless areas from logging. The Forest Service should clarify this intent in Appendix A of the Proposed Forest Plan, the suitable lands analysis. That analysis identifies Inventoried Roadless Areas as not suitable for timber production on legal grounds in "Step 1," since logging on those lands is prohibited by the Roadless Rule. 22 This is correct, but it should be made clear that even if the Roadless Rule were struck down by a court, or amended by USDA, the intent of this forest plan amendment is to preclude logging in roadless areas, as stated in the DEIS. Therefore, the "Step 2" analysis should specify that Inventoried Roadless Areas would be deemed not suited for timber production even if they lost their protection under Step 1.

RESPONSE

The intent behind the suitability analysis for this Forest Plan amendment is to identify lands that are suitable for timber production. As the 2001 Roadless Area Conservation Rule (Roadless Rule) generally prohibits commercial timber harvest in Inventoried Roadless Areas (IRAs), the IRAs on the Tongass National Forest are considered not suited for timber production. The designation of these lands as unsuitable in Step 1 meets the intent of FSH 1909.12, Section 61.1.1.

FSH 1909.12, Section 61.2 provides guidance on determining, from those lands identified as tentatively suitable in Step 1, the lands that are suitable for timber production based on all the multiple-use objectives for the forest. As the lands within the IRAs on the Tongass National Forest are no longer considered tentatively suitable for timber production, there is no need to review their suitability under Step 2 of this process.

COMMENT

RDLS-2: Support for Updated Roadless Inventory and Rulemaking to Remove "Roaded Roadless" from the Inventory.

We had hoped the agency would use this amendment process to support additional rulemaking and update the 2001 roadless area inventory. Such an update would have removed the so-called "roaded roadless" from the inventory, areas that were roaded before the 2001 Roadless Rule or during the eight years the Tongass was exempted from the 2001 Roadless Rule. A rule change would also conserve roughly 500,000 acres of roadless wildlands under the 2001 Roadless Rule excluded from the Tongass roadless inventory used for developing the 2001 Roadless Rule because of assumed logging development that never occurred. Such action would conserve remaining intact old-growth habitat, maintain existing carbon stocks, and increase carbon stored.

RESPONSE

Alternative 2 considered harvest within "roaded roadless" subject to rule making.

This amendment to the Tongass Forest Plan is using the IRA boundaries identified in a set of maps associated with the Final EIS for the Forest Service Roadless Area Conservation Rule, Volume 2, dated November 2000. These maps identify 9.2 million acres in IRAs on the Tongass, and correspond closely with the 1996 roadless area inventory that was prepared for the 1997 Forest Plan Revision (USDA Forest Service 1997c).

COMMENT

RDLS-3: Application of 2001 Roadless Rule Requires Clarification.

Chapter 1 of the DEIS states that "the Tongass has been subject to the Roadless Rule since 2011 and remains so today." DEIS at 1-4. The framework for Alternative 5 states "this alternative would allow old-growth harvest only within Phase 1 of the timber sale program adaptive management strategy." Since the Phase 1 portion of the timber base included some Inventoried Roadless Areas, please clarify that this statement only applies to the developed portion of the Phase I base.

RESPONSE

In Chapter 2 of the FEIS, the Framework and Expected Outcomes section for Alternative 5 clarifies that, "(a)s in Alternatives 1 and 4, the 2001 Roadless Rule would apply and no old-growth or young-growth harvest would occur in roadless areas." Thus, it is clear that no harvest is allowed in those Inventoried Roadless Areas identified in the maps associated with the Final EIS for the Forest Service Roadless Area Conservation Rule, Volume 2, dated November 2000. Table 2-14 in Chapter 2 of the FEIS also shows that no harvest is allowed in Inventoried Roadless Areas in Alternative 5.

COMMENT

RDLS-4: Inventoried Roadless Areas Need to be Maintained.

We support the preferred alternative's adherence to the Roadless Area Conservation Rule given that inventoried roadless areas provide unique ecosystem, wildlife, and climate benefits to the national forest systems18. Alternatives 3 and 4 would violate the roadless rule and should be dismissed on those grounds alone. The idea that this administration might undo landmark protections like this is genuinely unacceptable.

RESPONSE

We believe Alternative 3 is reasonable. The State of Alaska's challenge to application of the 2001 Roadless Area Conservation Rule (Roadless Rule) in Alaska is pending in the District of Columbia District Court. Alternative 3 would allow young-growth and old-growth harvest in 2001 Roadless Rule IRAs. If this alternative were selected, harvest in IRAs would be deferred until agency rulemaking modified 36 CFR 294(b)(4)(2001). 2001 IRAs are removed from lands suitable for timber production in Alternative 4.

However, three of the alternatives analyzed in detail (Alternatives 1, 4, and 5) allow no harvest in roadless areas.

COMMENT

RDLS-5: Decisions regarding resource development within Inventoried Roadless Areas should be delegated to the local Forest or District.

The May 2009 Decision by Secretary of Agriculture, Tom Vilsack, to arrogate to himself all decisions regarding resource development in IRAs in the Tongass National Forest (now delegated to the Chief of the Forest Service), added national politics to decision making on such issues as issuance of a Special Use Permit; a decision that had previously been made by the Tongass Forest Supervisor and District Rangers. The Secretary's control of what had been local decision making on the Tongass has drastically altered the assumptions upon which the Forest Plan was promulgated in January 2008. For example, even were the

Tongass still exempt from the 2001 Roadless Rule, the Washington Office of the Forest Service could refuse to allow a project that is in an IRA to go forward for political reasons. The Chief of the Forest Service should re-delegate to the Forest Supervisor and District Rangers on the Tongass the authority to make permitting decisions within IRAs.

RESPONSE

This recommendation is outside to the decision authority of the Forest Supervisor, the Responsible Official for this decision.

Specific Comments on the Forest Plan and DEIS (SPEC)

COMMENT

SPEC-1: Forest Service Should Reinstate the Deleted Beach and Estuary Management Standards and Guidelines.

RESPONSE

The amended plan includes changes specific to young-growth forest management. The beach and estuary fringe standards and guidelines (BEACH 2, III. Management, 6 and 7) in Chapter 4 were removed as part of this amendment because the standards and guidelines were changed as a result of updating the suitability of lands as it pertains to lands suitable for young-growth timber production. Under Alternatives 2, 3 and 5, young-growth stands within the beach and estuary fringe are identified as suitable for timber production. The applicable standards and guidelines were deleted from Chapter 4 and rewritten and replaced by forest-wide standard (S-BEACH-01) in Chapter 5 to reflect that lands in the beach and estuary fringe are not suitable for old-growth timber production.

COMMENT

SPEC-2: The Forest Service should reinstate the deleted karst resources standards and guidelines in Chapter 4 of the Forest Plan.

RESPONSE

The amended plan includes changes to young-growth forest management. The karst standards and guidelines (KC1, IV. Young Growth Management on Karst) in Chapter 4 were removed, rewritten, and added to the young-growth direction in Chapter 5.

COMMENT

SPEC-3: The Forest Service should reinstate the timber sale preparation standards and guidelines in Chapter 4 of the Forest Plan.

RESPONSE

Some language that is covered in Forest Service directives (e.g., Forest Service Manual, Forest Service Handbook) and direction used at project level planning was deleted from the DEIS version of the Forest Plan. We added content at the beginning of Chapters 3, 4 and 5 of the Forest Plan to state that the chapter assumes all laws, regulations, and policy pertaining to management of National Forest resources will be followed. We added much of this language back in for the FEIS version of the Forest Plan.

COMMENT

SPEC-4: The Forest Service should reinstate the road and bridge reconstruction – location and design, standards and guidelines in Chapter 4 of the Forest Plan.

RESPONSE

In the Transportation section in Chapter 3 of the DEIS (affected environment), a description was provided regarding the intent of the road construction to provide access to NFS lands. In these introductory paragraphs, the road maintenance level system is also described. In Chapter 4 of the Forest Plan in the Transportation section, the standards and guidelines provide direction for Transportation Planning in TRAN 3, Road and Bridge reconstruction in TRAN5, and the maintenance levels in TRAN 6 and TRAN 7. The aspects of location are not relative since the roads exist; however, some of the mechanisms for reconstruction relative to slope stability and reconstruction of stream crossing features as well as bridge abutments could be included.

COMMENT

SPEC-5: The young growth desired condition DC-YG-04 in Chapter 5 of the Forest Plan should be rewritten. Accelerating old-growth characteristics in Riparian Management Areas (RMAs) and the beach fringe through young-growth harvest has not been scientifically demonstrated. Ten-acre clearcuts are not similar to natural disturbance patterns and would: 1) set back decades of progress toward mature, uneven-aged stand structure; 2) further fragment the older young growth that now exists; and 3) compromise the integrity of the old growth Conservation Strategy.

RESPONSE

To meet the purpose and need, the forest identified the oldest young-growth stands as lands suitable for timber production to begin the transition away from old-growth harvest. Some of the oldest young-growth stands are located in RMAs and the beach fringe, where past harvest occurred, but where the current Forest Plan prohibited commercial harvest. The alternatives analyzed in the FEIS include various levels of young-growth harvest in these areas as well as a range of potential treatment types. Additionally, young-growth direction (i.e., plan components and management approaches) for the beach and estuary fringe are applied so as to minimize impacts to these areas while also allowing some of the oldest trees to be harvested in support of the transition. All project-level decisions implementing the 2016 Forest Plan must be consistent with the plan components.

Effects to the old-growth forest ecosystem are disclosed in the FEIS in the Biodiversity section in Chapter 3, and Appendix D for the FEIS specifically discusses effects to the old-growth Conservation Strategy.

See response to FISH-5.

COMMENT

SPEC-6: The Forest Service should change young growth suitability SUIT-YG-01 in Chapter 5 of the Forest Plan. The Old-growth Habitat LUD should not be identified as suitable for young-growth timber production because it lacks scientific justification.

RESPONSE

As stated in Chapter 2 of the FEIS (How the 2012 Planning Rule Applies), the responsible official has determined that for this amendment only a part of the substantive provisions of 36 CFR 219.11 apply for this amendment. Using the provisions of 36 CFR 219.11(a), specific young-growth stands are identified as suitable for timber production. Such stands include young growth in the beach and estuary fringe, riparian management areas, and in the Old-Growth Habitat LUD.

COMMENT

SPEC-7: The Forest Service young-growth objective O-YG-01 in Chapter 5 of the Forest Plan should be changed to end old-growth clearcutting in no more than five years.

RESPONSE

See responses to P&N-1 and ALT-4. Young-growth objective O-YG-01 in the Forest Plan was written to be a concise, measurable, and time-specific statement of a desired rate of progress toward a desired condition or conditions. That is to effectuate this transition, over the next 10 to 15 years, preserving a viable timber industry and allowing the forest industry time to adapt so that at the end of this period the vast majority of timber sold by the Tongass (i.e., gradually increase to exceed 50 percent of the timber offered annually) will be young growth.

COMMENT

SPEC-8: The young-growth objective O-YG-02 in Chapter 5 of the Forest Plan should be re-written to end to old-growth clearcutting before the end of the amended plan's lifespan, and preferably within five years, as one milestone within the overall 15 year transition.

RESPONSE

See responses to P&N-1, ALT-4, ALT-5, ALT-11, and SPEC-7.

COMMENT

SPEC-9: Forest Service should make the following changes to plan components for Wildlife in Chapter 5 of the Forest Plan.

9a The young-growth desired condition for wildlife DC-YG-WILD-01 in Chapter 5 of the Forest Plan should be changed to exclude active management of young-growth stands within the Old-growth Habitat LUD. The Old-growth Habitat LUD was set aside for ecological reasons and infringing onto those areas is not consistent with meeting social and economic needs. This LUD is a crucial component of the old-growth Conservation Strategy, and entering this LUD for young-growth timber production erodes the effectiveness of the Conservation Strategy and places undue risk on particular wildlife populations.

RESPONSE

See responses to CONS-1, PLR-1, PLR-2 and SPEC-6.

The Old-Growth Habitat LUD does play an important role in the overall Conservation Strategy. The Old-Growth Habitat LUD remains not suited for old growth timber production as in the 2008 Forest Plan. In some instances, young growth is within the boundary of this LUD and may not be fully functioning for wildlife needs. DC-YG-WILD-01 allows for young growth management within this LUD as long as habitat and connectivity is maintained and the treatment can move the stand toward old-growth characteristics. The Forest Plan also allows for an Old-Growth Habitat LUD to be modified to exclude young growth proposed for harvest if a net gain in old growth can be achieved through the boundary modification and Appendix K criteria can be met (see management prescriptions).

COMMENT

9b. The young-growth desired condition for wildlife DC-YG-WILD-02 in Chapter 5 of the Forest Plan should be rewritten. Ten-acre clearcuts do not emulate the natural scale and distribution of disturbance patterns, and there is no science to support this. The Forest Service should consider restoration treatment methods that would increase habitat value in second-growth forests, such as removing 1-3 trees in widely spaced gaps.

RESPONSE

See response to SPEC-6.

Desired conditions describe specific social, economic, and/or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed. Desired condition DC-YG-WILD-02 ensures that young-growth treatments in the Old-growth Habitat LUD do not foreclose the opportunity to maintain or achieve natural scale and distribution of disturbance patterns over the long term. Young-growth standard S-YG-WILD-01 constrains the maximum size of openings to not exceed 10 acres. Specific harvest prescriptions will be determined at the project level after site-specific analysis by an interdisciplinary team of resource specialists. Project decisions must describe how the project is consistent with plan components, including meeting the desired conditions (see DC-YG-WILD-01 and DC-YG-WILD-02) if young-growth harvest is taking place in an Old-Growth Habitat LUD.

COMMENT

9c. Young-growth objective for wildlife O-YG-WILD-01 and young-growth standards for wildlife S-YG-WILD-01 and S-YG-WILD-02 in Chapter 5 of the Forest Plan should be removed because the Old-growth Habitat LUD should not be entered for young-growth harvest.

RESPONSE

See response to SPEC-6.

Objectives are measurable and time-specific statements to indicate the desired rate of progress toward desired conditions. Objective O-YG-WILD-01 estimates the number of acres to be treated over a 15 year time period to promote the development of old-growth characteristics within the LUD, and ensures that young-growth treatments in the Old-growth Habitat LUD do not foreclose the opportunity to maintain or achieve the development of old-growth characteristics over the long-term.

Standards are mandatory constraints on project and activity decision-making, established to help achieve or maintain the desired condition or conditions, to avoid or mitigate undesirable effects, or to meet applicable legal requirements. This standard provides the constraints on commercial young-growth harvest to help achieve or maintain old-growth characteristics within the Old-growth Habitat LUD.

Standard S-YG-WILD-01 does not require the Old-Growth Habitat LUD to be entered nor does it require 10 acre openings. Rather, it constrains the maximum opening size and percent of stand removal. Every project analysis will use an interdisciplinary approach to review site-specific conditions and determine the harvest prescription that will best meet the desired conditions. Similarly, Standard S-YG-WILD-02 does not require the Old-Growth Habitat LUD to be entered. If a project proposes commercial young-growth harvest in this LUD, this standard provides a constraint for a one-time entry within the first 15 years of Plan approval, unless there is a compelling need to do so based on the best available science and to meet the LUD objectives. (Consult Chapter 3 Old-Growth Habitat LUD objectives.) In addition, an Old-Growth Habitat LUD with proposed young-growth harvest may be modified using Appendix K criteria, using an interagency review process, to exclude the proposed young-growth and include a net gain of old-growth from the adjacent landscape. (See Wildlife Management Approaches.)

COMMENT

9d. The young-growth goal for wildlife G-YG-WILD-01 in Chapter 5 of the Forest Plan should be re-written to state that no new roads should be built in the Old-growth Habitat LUD.

RESPONSE

The management prescription for the Old-growth Habitat LUD includes standards and guidelines for transportation (see Old-growth Habitat LUD Transportation Operations: TRAN in Chapter 3). Since the Old-growth Habitat LUD has been identified as suitable for young-growth timber production in the amended plan (see response to SPEC-6), goal G-YG-WILD-01 was written to ensure that roads used to access young-growth were kept to a minimum. Projects or activities must be consistent with this goal, as well as all other applicable plan components, such as DC-YG-WILD-01.

COMMENT

SPEC-10. Forest Service should make the following change to the plan component for Transportation Systems Corridors Direction in Chapter 5 of the Forest Plan.

The Transportation Systems Corridors objective O-TSC-01 should focus on improvements to existing travel corridors rather than new roads in areas with high road density. This is particularly an issue in areas on Prince of Wales Island where wolf mortality has increased in proportion to road density.

RESPONSE

Objectives are measurable and time-specific statements to indicate the desired rate of progress toward desired conditions. Objective O-TSC-01 is tied to Forest Desired Condition DC-03 in Chapter 5 of the Forest Plan.

The purpose of transportation systems corridors is to facilitate the availability of National Forest System lands for the development of existing and future transportation systems corridors such as those identified by the State of Alaska's Southeast Alaska Transportation Plan and applicable laws (for example, Section

4407 of P.L. 109-59, Title XI of the Alaska National Interest Lands Conservation Act, P.L. 96-487). These transportation system corridors are not part of the forest transportation system (see Chapter 7 glossary), such as roads that are used for timber harvest.

At the project level, an interdisciplinary team of resource specialists analyzes the site-specific resource concerns such as road density and provides that information to the public and the responsible official (decision-maker) to determine the best course of action, which may include relevant mitigation measures.

COMMENT

SPEC-11: Forest Service should add a standard and goal for Transportation Systems Corridors direction in Chapter 5 of the Forest Plan.

11a. The Forest Service should aim for no net gain in roads and add a standard for wildlife to the Transportation Systems Corridors direction in Chapter 5 of the Forest Plan to maintain road densities within Wildlife Analysis Areas (WAAs) at less than 0.7 mi/mi^2. If a new road goes into a particular WAA, the Service should close or decommission the equivalent road mileage within the same WAA.

RESPONSE

The Transportation Systems Corridors direction in Chapter 5 of the Forest Plan does not address the forest transportation system (see definition in Chapter 7 glossary). Chapter 4 of the Forest Plan includes Transportation standards and guidelines (see Transportation Improvement Planning: TRAN3; Road Maintenance: TRAN6; and Road Decommissioning: TRAN7), but there are no WAA road density thresholds.

The Transportation section in Chapter 3 of the FEIS (affected environment) describes the intent of the road construction to provide access to NFS lands. There is a discussion of road density and WAAs included in the Wildlife section in Chapter 3 of the FEIS (environmental consequences) and Table 3.10-12 compares by alternative the estimated average road density and percent of WAAs in road density categories on National Forest System lands and all lands combined, and a measurable increase is not anticipated.

Road closures are determined through an access travel management plan and project level planning efforts.

Standards and Guidelines are included under the primary resource that is driving that particular standard. In this case, the suggested standard and guideline are primarily a wildlife concern not a transportation concern. WILD1.XIV.A.1(c) on page 4-88 includes a similar road density in areas where wolf mortality concerns have been identified and road access was determined to be a significant contributing factor. An interagency Wolf Technical Committee has been established and is currently working on issues related to wolf management concerns.

COMMENT

11b. A goal for wildlife should be added to Transportation Systems Corridors direction in Chapter 5 of the Forest Plan to maintain the ability for wildlife to withstand illegal hunting pressure and should depend on limiting WAAs to road densities of less than 0.7 mi/mi^2. In WAAs that already exceed the 0.7 mi/mi^2 threshold, the Forest Service should actively close and decommission roads in order to alleviate the hunting access pressure in those areas, paying special attention to GMU 2.

RESPONSE

This request is outside of the scope of this focused amendment. Road management decisions are best made at the local planning unit in response to specific conditions. This type of change is best considered during a revision. It is notable, however, that road densities are expected to grow at a much lower rate than were predicted by the 1997 Forest Plan, under which the Conservation Strategy and species viability

were evaluated. The same is true of the level of old growth remaining after 100 years, being substantially greater under the current amendment alternatives than under the 1997 Forest Plan.

COMMENT

SPEC-12: Regarding the forest wide timber objectives O-TIM-01 and O-TIM-02 in Chapter 5 of the Forest Plan, the Forest Service should articulate a schedule for decreasing old-growth timber to ensure an end to old-growth clearcut logging before the end of the Plan, and preferably within 5 years of the Plan's implementation. Any post-transition harvest of old growth should be accomplished by single or small group tree selection rather than clearcutting. The overall forest transition may require moving away from even-flow timber harvest, allowing greater flexibility in annual harvest quotas.

RESPONSE

The Forest Plan is a broad plan that defines the appropriate uses in the Forest, sets overarching goals and objectives for the land use designations on the forest. The Forest Plan also sets forth desired conditions that describe specific social, economic, and/or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed.

Specific prescriptions are developed at the stand level that are designed to meet forest plan goals and objectives, to move the stand towards a desired condition while considering the stand's current condition. Developing specific prescriptions at a Forest Plan level may not allow for flexibility at the stand level to account for the unique conditions that can be found at the stand level.

See response to Alt-4 and SPEC-7.

COMMENT

SPEC-13: The beach and estuary fringe, RMAs, and the Old-Growth Habitat LUD should be changed to not suitable for timber production in Appendix A of the Forest Plan.

RESPONSE

See response to SPEC-6.

Appendix A represents Alternative 5 (preferred alternative) and reflects final TAC recommendations (Forest Plan Appendix B). The TAC recommendations included commercial young-growth harvest in these areas. Appendix A in the Forest Plan has been updated and identifies lands as not suitable for old-growth timber production in the beach and estuary fringe, RMAs, and Old-Growth Habitat LUD, but suitable for young-growth timber production in these areas.

COMMENT

SPEC-14: The Forest Service should clarify the language in the forest plan regarding the status of lands in development LUDs that are not suitable for timber production, as well as other areas, such as The Nature Conservancy/Audubon priority conservation areas that are not suitable for timber production.

RESPONSE

Appendix A of the Forest Plan has been updated to reflect the preferred alternative and clarifications have been made.

COMMENT

SPEC-15: Incorrect potential entitlement for 5 new urban Native corporation – total acres is 115,000, not 184,320.

RESPONSE

The potential entitlement is 115,200 acres and the correction will be made. The text of the Senate Bill S.872 introduced on 3/26/2015 reads as follows:

"SEC. 43. URBAN CORPORATIONS FOR HAINES, KETCHIKAN, PETERSBURG, TENAKEE, AND WRANGELL.

"(a) OFFER OF COMPENSATION.—

"(1) IN GENERAL.—On incorporation of the Urban Corporations for Haines, Ketchikan, Petersburg, Tenakee, and Wrangell, the Secretary, in consultation and coordination with the Secretary of Commerce, and in consultation with representatives of each such Urban Corporation and the Regional Corporation for Southeast Alaska, shall offer as compensation, pursuant to this Act, 1 township of land (23,040 acres) to each of the Urban Corporations for Haines, Ketchikan, Petersburg, Tenakee, and Wrangell, in accordance with this subsection."

COMMENT

SPEC-16: As the dominant strategy for managing young-growth forests within old-growth habitat reserves, the Forest Service should develop an "old-growth restoration" management prescription that has been scientifically well vetted with a panel of experts.

RESPONSE

The Forest Plan is a broad plan that defines the appropriate uses in the Forest, sets overarching goals and objectives for the land use designations on the forest. The Forest Plan also sets forth desired conditions for each of the Specific prescriptions are developed at the stand level that are designed to meet forest plan goals and objectives, to move the stand towards a desired condition while considering the stand's current condition. Developing specific prescriptions at a Forest Plan level may not allow for flexibility at the stand level to account for the unique conditions that can be found at the stand level.

The Forest has implemented several scientifically rigorous studies that are designed to quantify how various prescriptions can meet specific objectives that are designed to improve wildlife habitat and move a stand towards old-growth conditions. The Tongass-wide Young-Growth Study (TWYGS) was begun in 2001. TWYGS is helping increase the knowledge of thinning and response of tree and plant vegetation. The plan is expected to continue for 20-30 years, if funding and support continue. The results of TWYGS should increase our knowledge of effects of thinning, inter-planting alder, pruning, girdling, and slash treatment for various objectives, including wildlife habitat improvement, and timber production.

The Prince of Wales Commercial Thinning Study was awarded as an integrated resources service contract at the end of FY2008. This study looks at 5 different commercial thinning prescriptions that offer a range of potential treatments that could be used on the Tongass. The 5 different prescriptions were implemented at three replicates: near Harris River, in the Maybeso Experimental Forest, and near Naukati. The objectives of the study are to assess how mechanized equipment operates, how the different prescriptions hold up to SE Alaska's weather, and what the understory response is after treatment. Long-term monitoring is helping to understand how a treated stand moves towards achieving old-growth structure.

COMMENT

SPEC-17: Young-growth harvest in RMAs (in or outside TTRA buffers) should only be allowed for habitat enhancement (e.g., to accelerate stand development toward old-growth conditions). One of the key processes and characteristics of old growth that is critical for the riparian zone is the creation of coarse woody debris inputs to streams which create diverse and structurally important habitats for aquatic invertebrates and fish. Using wide spaces in thinning treatments can more quickly grow large trees, which would provide these critical structures.

RESPONSE

In order to meet the timeline for the young growth transition as outlined in the undersecretary's memo, all young growth lands were considered. Since the age of the young growth stands is a limiting factor, the oldest stands of young growth are being considered for harvest to facilitate the transition. If the oldest young growth stands are not included in the earliest phase of the transition, it is highly unlikely we could meet the purpose and need of the amendment. Therefore, old growth timber harvest would continue for a longer time period.

Most of the large woody debris recruited to stream channels would occur from the TTRA buffer. However, some reduction in woody debris in stream channels could occur in RMAs outside of the TTRA buffer depending on alterative. Riparian Management objectives would be maintained as proposed under Alternatives 1, 3, and 4. Alternatives 2 and 5 require that management in young growth riparian areas accelerate old-growth characteristics to improve riparian function, but would allow some harvest in young-growth outside of TTRA buffers (refer to Water section). Alternative 2 allows only for commercial thinning of up to 33 percent of stand basal area over more than 36,000 RMA acres. This Alternative would likely have additional adverse effects to fish habitat not common to the other alternatives and could result in a loss of large woody debris to portions of floodplain and alluvial fan channel types. While Alternative 5 allows up to 10 acre open area cuts and commercial thinning totaling no more than 35 percent of the total stand acres, it is restricted to less than 900 acres of total harvested RMA area and will only occur in the first 15 years of the finalization of the Plan Amendment. With these restrictions, the overall areas affected would be small relative to the total available in the Tongass. A watershed analysis (as described in Forest Plan Appendix C) would be needed for implementing any alternative that proposed to enter the RMA. Per Plan Chapter 5 Management Approaches for Riparian, it is expected that the first priority for wood removed from RMAs will be to support local stream restoration needs.

COMMENT

SPEC-18: Specific Comments on Economic and Social Environment section of DEIS.

Nowhere in the Economic and Social Environment section on wood products is there any discussion on the cost to harvest and produce a manufactured product, either lumber or biomass (see lumber price graph). Please provide this missing information. Based on information on page 3-481 revenue estimates were made in the document. Based on this information when combining estimated yearly revenue for all timber sale within an alternative, as shown in text figures, results in some years projected into the future with negative revenue. Negative revenue would violate federal laws for federal timber sales. The estimated revenue values used for timber sales also does not include subsidies that the Forest Service contributes through sale preparation, support and administration and therefore estimates of positive review from the proposed options of timber sales are incorrect.

Using the discounted net revenue number for Alternative 5 from Table 3.22-16, the USFS is saying it will average a positive return of ~$98/MBF ($112.9 million divided by (46MM(annual volume) *25years)) over a 25-year period after subtracting its administrative cost.

RESPONSE

The statement on p. 3-481 in Chapter 3 of the DEIS under Financial Analysis has been corrected in the FEIS to refer to the costs used by the R10 Appraisal program instead of Forest Service administrative costs. The Forest Service administrative costs are not relevant to a programmatic EIS such as the Forest Plan Amendment since there is no actual volume (MMBF) realized through the NEPA process. Instead these costs are disclosed in project timber harvest EISs.

The correct costs used to determine the information on including the estimated logging costs associated with old growth harvest and young growth and estimated road and other transportation costs, are now disclosed in detail in Chapter 3 of the FEIS in the Economic and Social Environment section (affected environment) under "R10 Appraisal Costs."

The FEIS also discusses the fact that these estimates represent only a snapshot in time, and that they may change at the time of sale and are useful primarily for comparing alternatives. The R10 Appraisal was used as a tool for financial analysis and alternative comparison at the programmatic EIS level; it does not yield a timber sale appraisal. When actual timber sales are sold from a project after environmental analysis, the appraisal is based on the current appraisal bulletin, cost information, and a profit and risk allowance to determine stumpage values at the time of offering.

COMMENT

SPEC-19: When economics are relevant and important to a decision, economic information must be included in an EIS.

According to 40 CFR 1502.23, when economics are relevant and important to a decision, economic information must be included in an EIS.

> The DEIS documents do not detail the PLV used by the USFS. What is the PLV number for YG? What is the PLV for OG? Nothing in the documents tells the reviewer how the USFS determined the PLV and cost of future harvest 25 and 100 years out. Did the USFS use a set percentage increase over time? Please provide this missing information.
>
> In Appendix B (pg. B-13) when they performed the modeling exercise they used only the five southern districts on the Tongass for the first 15 years. By not considering/using the entire Tongass they misrepresent the actual cost of harvesting timber from the forest. See TWFG paper, *Analysis of Old Growth Inventory and Land Base Available for Operations within the Tongass National Forest, 2014*. In that document the cost of transportation from the northern part of the Tongass to the Viking mill in Klawock drives most volume available for harvest into negative value territory.
>
> Based on the Woodstock model (see attached TWFG sheet) for Alternative 5 and the statement on pg. 2-32 of the DEIS, by year 16 the volume of OG harvest will be reduced to 5MMBF per year or a total of 25MMBF for the period years 16-20. The Woodstock model shows the 25MMBF of OG producing a net return of $360.9/MBF. Refer to the net returns for Saddle Lakes and Big Thorne; the USFS has not produced an OG timber sale that generates a net return after administrative cost of $360.99.

Corrections or Revisions Needed

Page 3-450, DEIS: Table 3.22-5 shows the average timber harvest for State lands is 25.7 MMBF for the last 13 years; the average for the last seven years is a much lower 12.3 MMBF. The last seven years is a better indication of future volume based on the fact that Alaska Mental Health Trust and the University are not bound to manage on a sustained-yield basis.

RESPONSE

A cost-benefit analysis has not been displayed as a strict quantitative monetary analysis due to the many other considerations that must be given to other resources that have no dollar value assigned as 40 CFR 1502.23 recommends “For purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations” (emphasis added). An analysis of the effects for each resource has been included with the ‘costs’ and ‘benefits’ explained either quantitatively or qualitatively. A summary of the effects by Alternative and the comparison of alternatives for each of the significant issues is in Chapter 2. In addition, a discussion of the Tongass Old-growth Conservation Strategy is displayed in the Forest Plan Amendment DEIS, Appendix D.

The pond log values are located on the RV spreadsheets. While this information is not included in the FEIS which is the summary of the analysis done for this amendment, they are located in the planning record.

The southern five districts were used instead of the entire Tongass National Forest due to their proximity to the majority of the existing mills. Timber harvest projects could occur on the northern part of the Tongass but would probably need to be 100% exported such as the Yakutat sale in the mid-2000s.

The analysis that you mention for Big Thorne and Saddle Lakes EISs were run using FASTR and used the volume for the entire alternative and much of this volume is of lower grades than is found in small sales and microsales which target larger, higher value trees destined for higher end value-added manufactured for products.

COMMENT

SPEC-20: Correction on open roads in non-NFS lands needed in Appendix C.

Page C-4, DEIS: Table C-1 breaks down past road construction and states that 3,379 miles out of 3,660 miles of roads constructed on non-national forest land remain open. Based upon the Division of Forestry's best estimate, instead of 92% remaining open, the total still open is more likely in the range of 1500-2000 miles, or about 50%.

RESPONSE

As suggested, the proportion of all roads in open vs. closed status is not readily available for non-NFS lands. The Forest Service based the DEIS estimate on available GIS information, and has decided to use the State's estimate of 50 percent for the FEIS. The numbers in Appendix C have been updated where information was available.

COMMENT

SPEC-21: Specific Wildlife-related Comments on DEIS.

Page 2-7, Wildlife, DEIS: Please consider managing habitat to provide for sustainable wildlife populations rather than viable populations.

RESPONSE

Forest Plan Chapter 2 includes the following forest-wide goal for wildlife:

"Maintain the abundance and distribution of habitats, especially old-growth forests, to sustain viable populations in the planning area."

See response to PLR-2.

COMMENT

Pages 2-14 through 2-20, Alternative 2, DEIS: Please provide a clearer description of how harvest in the beach buffer occurs. Include discussion of the anticipated effects on MIS when the 1,000 ft beach buffer is removed for harvest and road construction. Please expand the discussion of how leaving an adjacent inland stand of POG or young growth serves the purpose of the beach buffer. It would be helpful to focus this discussion on biogeographic provinces 13 and 14. See our similar comments for Appendix D on page 4.

RESPONSE

Chapter 2 of the FEIS describes the alternatives in detail, including tables and figures. The alternative description states whether young growth may be harvested in the beach and estuary fringe, how it can be harvested (e.g., clearcutting, commercial thinning), where it can be harvested, and how much young-growth volume the alternative yields. In terms of describing how harvest in the beach and estuary fringe would occur, the Forest Plan provides the actual management prescription; not the FEIS. Each Land Use Designation (LUD) has a management prescription. Each management prescription includes the following elements: 1) Land Use Designation Standards and Guidelines; 2) Forest-wide Standards and Guidelines (Chapter 4); and 3) Plan Content Developed Under the 2012 Planning Rule (Chapter 5). Chapter 5

includes plan components and management approaches for young-growth harvest in the beach and estuary fringe that provides direction for an IDT when designing and implementing a project.

The Forest Plan Amendment does not propose to remove the 1,000-foot beach buffer. Rather, as under Alternative 5, a minimum 200-foot-wide forested buffer along the shoreline adjacent to young-growth harvest units is required, which would continue to protect forest in the beach and estuary fringe for connectivity and habitat while the harvested stand matures. (See Chapter 5 young-growth standard S-YG-BEACH-03.) Thus, the functioning of the beach and estuary fringe may be reduced in places due to the reduced buffer, but effects would be short-term and more localized. (See FEIS Appendix D, Beach and Estuary Fringe section.)

The FEIS provides a programmatic analysis that addresses the Forest Plan. A programmatic analysis of a Forest Plan includes a set of policies and maps of possible future activities and uses, the specifics of which are not yet known. Any future development, if and when it does take place, would result in effects. It is reasonable, therefore, to foresee that on-the-ground impacts would occur if the Forest Service harvests young-growth in the beach and estuary fringe. An analysis of each alternative and discussion about the anticipated effects from harvesting young growth in the beach and associated road construction is included under each resource section in FEIS Chapter 3 including Biodiversity and Wildlife. Because the FEIS is analyzing an amendment to the 2008 Forest Plan developed under the 1982 Planning Rule, these species are analyzed even though the 2012 Planning Rule does not use MIS for evaluating effects. Most of these species are associated with POG forests of Southeast Alaska either directly or rely on prey species associated with these habitats.

The Forest Plan provides young-growth direction for the beach and estuary fringe. The FEIS in the Chapter 3 Biodiversity and Wildlife sections describe and analyze young-growth harvest in the beach and estuary fringe. FEIS Appendix D also provides a similar analysis, and also includes several tables that facilitate understanding the anticipated effects. Table 6 summarizes distribution of young-growth harvest acres (over 100 years) within the beach and estuary fringe by Biogeographic Province and Alternative.

Due to the localized nature of anticipated effects, under all of the alternatives the beach and estuary fringe would continue to act as a transition zone between interior forest and saltwater influences, maintain landscape connectivity, and provide benefits to the marine environment across the planning area. Therefore, it would be expected that there may be localized reductions in the ability of the beach and estuary fringe to function as intended under the Conservation Strategy under each of the alternatives but Forest-wide effects would not measurably reduce the functioning of this contributing element of the Conservation Strategy.

COMMENT

Page 3-223, DEIS: Please update this section to reflect the Fish and Wildlife Service decision announced on January 5, 2016 that the Alexander Archipelago wolf does not warrant protection as an endangered or threatened species under the Endangered Species Act.

RESPONSE

Chapter 3 of the FEIS, Wildlife Section (Alexander Archipelago Wolf) has been updated to include a discussion regarding the USFWS publishing a 12-Month Finding that listing of the subspecies was not warranted.

COMMENT

Page 4-100, DEIS: We recommend eliminating the distinction between peregrine falcon subspecies given recent studies about the subspecies status along parts of coastal Alaska.

RESPONSE

Changes to Chapters 3 and 4 of the Forest Plan were minimized during this amendment. Direction related to the purpose and need of this narrow amendment (young growth, renewable energy, transportation systems corridors) was modified as appropriate. The suggested change is not necessary to accomplish the narrow focus of this amendment.

COMMENT

SPEC-22: Specific Wildlife-related Comments on the Proposed Plan.

Page 2-8, Wildlife, Proposed Plan: Replace the term *sport* with *hunting*.

RESPONSE

The Forest Service restored some wording deleted in the Proposed Forest Plan. Public comments expressed concerns about the "breadth" or expansiveness of these changes, giving the appearance of a broad-based amendment. (See P&N-8, PLR-3) Although these changes are administrative, for clarity sake, the changes have been restored to the original language. Therefore, the suggestion to change terms in Chapter 2 was not included.

COMMENT

Page 3-10, Desired Condition, paragraph 1, Proposed Plan: Define appropriate research, how the determination is made, and what role the State plays in the process.

RESPONSE

In Chapter 3, LUD-specific standards and guidelines provide direction for implementation of projects. It is not the location to give specifics on operating procedures such as how special use requests for research are determined. Research may be proposed and conducted by a variety of partners and agencies, which may include the State of Alaska, universities, non-profits, and others. Forest Plan guidance is not intended to list the role of partners and cooperators for each activity that could be authorized.

COMMENT

Page 3-45, Proposed Plan: Consider adding a land use designation (LUD) standard and guideline under the wildlife habitat improvement heading that addresses non-native wildlife management following a natural disturbance or disease.

RESPONSE

Changes to Chapters 3 and 4 of the Forest Plan were minimized during this amendment. Direction related to the purpose and need of this narrow amendment (young growth, renewable energy, transportation systems corridors) was modified as appropriate. Therefore, the suggestion to add a new standard and guideline to the Research Natural Area LUD is not included as it is beyond the scope of the amendment.

COMMENT

Page 3-57, Desired Condition, Proposed Plan: Clarify how a population of a species is defined as a subspecies. Consider revising the definition on page 7-42 and consult the ADF&G draft Wildlife Action Plan for more information on subspecies (2015).

RESPONSE

LUD specific standards and guidelines is not an appropriate place to define / clarify terminology.

COMMENT

Page 3-138, Wildlife, Proposed Plan: Please clarify the author and standing of the Tongass Young Growth Management Strategy referenced here. The document could be strengthened by adding

more information regarding the effects of the strategy to wildlife. The version available through the references (Page 6-49, DEIS) does not contain Exhibit 3.

RESPONSE

The Tongass Young Growth Strategy is included in the Planning Record. The Forest Plan now indicates the Tongass Young Growth Management Strategy is an unpublished US Forest Service document.

COMMENT

Page 4-96, Proposed Plan: We recommend adding standards and guidelines for protection of the Pacific marten *Martes caurina*, which is endemic to Admiralty and Kuiu Islands. Macdonald and Cook (2007) and Dawson (2008) are good resources.

RESPONSE

The FEIS acknowledges both American and Pacific marten and discusses that the existing Forest Plan guidance on marten (WILD1. XVIII) is intended to apply to all marten across the Tongass National Forest. Accordingly, no additional standards and guidelines specific to Pacific marten were added to the Forest Plan.

COMMENT

Page 4-99, Proposed Plan: Please replace goshawk nest stand with nest site. The monitoring protocol could be strengthened by ensuring the assumptions of nest identification and the probability of detection is valid. ADF&G biologists are interested in helping USFS biologists develop the monitoring program. We are concerned about the efficacy and statistical validity of the current goshawk monitoring program.

RESPONSE

Most of the goshawk standard and guideline (WILD4.II) refers to nest site. The one instance where it says “nest stand” is intended to mean the minimum 100 acre nest buffer area, which is appropriately referred to as a “stand.”

COMMENT

Page 5-8, Management Approaches, Proposed Plan: This section would benefit from clear goals and objectives related to monitoring the effects of young-growth harvest on MIS. See our similar comments for Appendix D on page 4.

RESPONSE

Monitoring is outlined in the Tongass Plan Monitoring Program (USFS 2016). The monitoring plan is no longer included within the Forest Plan (was Chapter 6 in the 2008 Forest Plan), but is now a separate document. Management approaches in Chapter 5 of the Forest Plan, describe the intent or expectations of the responsible official in terms of the applicable plan components, such as a desired condition or standard for the affected resource.

COMMENT

SPEC-23: Specific Wildlife-related Comments on Appendix D of the DEIS.

Page D-3: This section summarizes the scope of analysis and acknowledges new science. As in the DEIS, the analysis does not adequately describe how young-growth harvest affects wildlife species. Similarly, the DEIS and the section on the contribution of matrix lands lacks adequate analysis and should be strengthened with references from land management focused research conducted on the Tongass.

RESPONSE

The purpose of this section was not to describe how young-growth harvest affects wildlife, but rather to highlight new science related to the contribution of young-growth stands to conservation. This section

specifically notes that transition to young-growth management under this Forest Plan amendment has the potential to both positively and negatively affect the condition and quality of matrix lands, and thus their contribution to the Conservation Strategy. The subsequent discussion in Appendix D describes the potential adverse effects to wildlife associated with young-growth harvest, including:

- Young-growth harvest within the Old-growth Habitat LUD and other non-development LUDs has the potential to increase habitat fragmentation and reduce the ecological contribution of young-growth stands to the reserve system by setting back the trajectory toward late seral forest condition by delaying the development of old-growth stand characteristics such as snags, downed logs, and diverse tree canopy layers required by some POG-associated species (e.g., marten, goshawks, flying squirrels);
- Young-growth harvest in the beach and estuary fringe has the potential to locally decrease buffer width and reduce its effectiveness in facilitating the movement of organisms across the landscape and providing habitat for wildlife species that are negatively affected by edge; and
- Young-growth harvest in the RMA has the potential to locally decrease buffer width and reduce its effectiveness in facilitating the movement of organisms across the landscape and reduce the function of riparian areas.

COMMENT

Page D-4, paragraph 2, DEIS: Stating young growth serves as dispersal corridors between old-growth stands is a generalization, as young-growth stands can be barriers rather than corridors for some old-growth associated species. Please revise.

RESPONSE

The purpose of this section was to note the growing recognition, which was acknowledged during the development of the 1997 Forest Plan, of the ecological function that young-growth stands and matrix lands in general play in conservation. A statement has been added to Appendix D noting that young-growth stands can act as barriers. Throughout Appendix D, the adverse effects of young-growth harvest are discussed (see response to SPEC-23).

COMMENT

Page D-5, paragraph 3: The USFS states that on a forest-wide basis, over 90% of the existing POG will be protected from harvest. Given the context, this statement implies that forest management will have little effect on old-growth associated species because 90% of their habitat will remain intact. However, populations of many old-growth associated species are confined to islands or biogeographic regions where a much higher proportion of POG has been or will be harvested. We recommend that relative to wildlife, such habitat summaries be presented at a scale that is meaningful to the species or populations being discussed.

RESPONSE

For all analyses related to old-growth retention and proposed young-growth harvest in non-development LUDs, RMAs, or the beach and estuary fringe results included in the Wildlife and Biodiversity sections of the EIS and in Appendix D, which addresses the Forest Plan Conservation Strategy specifically, results are presented Forest-wide and by biogeographic province. The breakdown by biogeographic province is intended to provide context for the spatial distribution across the Forest of potential effects given that some portions of the Tongass have been more affected by past timber harvest than others. Where appropriate, a discussion of particular areas of the Tongass where effects to wildlife species are more likely to occur is included in the species-specific discussions and in the cumulative effects discussion in the Wildlife section of the EIS.

COMMENT

Page D-5, paragraph 4: To help the reader get a better sense of the scale of changes resulting from GIS mapping updates, please add text and a table describing how the changes affected the wildlife habitat analysis. For example, provide the number of polygons/acres in a given bioregion found to be >150 years old and corrected to size class 4, resulting in increased POG acreage in a bioregion.

RESPONSE

Mapping updates occur on an ongoing basis for various reasons. Mapping updates that have happened periodically since 2008 have been incorporated consistently in the description of existing conditions and in the evaluation of each alternative. Additional updates were made between the DEIS and FEIS to provide the best available information. See Chapter 1 of the FEIS for a discussion of changes between the DEIS Updates. GIS data used in the FEIS is available in the project record.

COMMENT

Page D-12: Please provide a clearer description of how harvest in the beach buffer occurs under Alternative 2. Include discussion of the anticipated effects on MIS when the 1,000 ft beach buffer is removed for harvest and road construction. Please expand the discussion of how leaving an adjacent inland stand of POG or young growth serves the purpose of the beach buffer. It would be helpful to focus this discussion on biogeographic provinces 13 and 14, which have the highest level of this type of harvest under Alternative 2. See our similar comments for the DEIS on page 3.

RESPONSE

Page D-15 of Appendix D describes harvest proposed under Alternative 2 within the beach and estuary fringe. The most intensive young-growth harvest in the beach and estuary fringe would occur under Alternative 2 which would allow clearcutting to the shoreline during the first 15 years after plan approval and commercial thinning thereafter (see Table 2 in Appendix D which describes the harvest prescriptions proposed within the beach and estuary fringe by alternative). A statement has been added to the above referenced paragraph that conveys that by shifting the beach and estuary fringe inland, the level of connectivity between watersheds would be maintained but the ability of the beach and estuary fringe to serve as a transitional zone between interior forest and marine influence would be locally reduced.

COMMENT

Page D-17, paragraph 4: Please clarify the statement that individual islands function as metapopulations for some species.

RESPONSE

This statement has been clarified to state that this relates to species that do not typically disperse between islands.

COMMENT

Page D-18, paragraph 7: This section would benefit from clear goals and objectives related to monitoring the effects of young-growth harvest on MIS. See our similar comments for the DEIS on page 3. ADF&G is available to help develop the monitoring questions.

RESPONSE

Modifications to monitoring questions, and revision of the Monitoring and Evaluation program are outside of the scope of this EIS. In a separate process, the Tongass recently published a draft Plan Monitoring Plan on March 9, 2016 for a 30-day comment period. The new Plan Monitoring Plan was adopted on May 9, 2016. The final monitoring plan is posted at http://www.fs.usda.gov/goto/R10/Tongass/Monitoring.

Future administrative changes may be necessary after completion of the ongoing Forest Plan Amendment. In addition, the Tongass is deferring action on two requirements: focal species and species of conservation concern. The requirement to monitor the status of focal species to assess ecological conditions is in 36 CFR 219.12(a)(5)(iii) and the requirement to monitor the status of ecological conditions to maintain viable populations of species of conservation concern is location at 36 CFR 219.12(a)(5)(iv). Once these species and their associated ecological conditions have been identified, relevant monitoring questions will be added or modified as necessary. The public would be notified of any substantial administrative changes and would have the opportunity to comment at that time.

COMMENT

SPEC-24: Specific Fish-related Comments on the DEIS (SOA-016)

Page 3-31, DEIS: Include discussion and citation of literature regarding how increased harvest in the riparian management area (RMA) in moderate vulnerability karst landscapes could impact diffuse recharge and stream water quality.

RESPONSE

The 2008 Amended Forest Plan, Appendix H, V. Young-Growth Management on Karst, Page H-8 states that; "Commercial thinning is appropriate on low to moderate vulnerability karst lands when the karst management objectives can be met." Preliminary data (Prussian, 2011) does support the concept that by commercial thinning of the older young-growth stands on karst, returning the stand to closer-to-pre-harvest tree spacing, thus hastening the hydrologic recovery of the site. Reducing the canopy cover could restore the 'health' of young growth forests on karst lands by increasing the volume of throughfall, flushing sedimentation out of diffuse and discrete karst openings, and reconnecting surface to subsurface flow pathways. With increased recharge, karst springs should contribute more to the aquatic systems. Wissmar et al. 1997 and Bryant et al. 1998 documented a higher productivity in karst influenced streams than in other streams. The karst landscape influences productivity of its aquatic habitats in several ways. The geochemistry associated with karst development contributes to productivity of aquatic environments through its carbonate buffering capacity and carbon input dissolved from the limestone bedrock (Wissmar et al. 1997). This action has significant downstream effects on the aquatic food chain and biotic community. Preliminary studies suggest that aquatic habitats associated with karst landscapes may be 8 to 10 times more productive than adjacent, nonkarst-dominated aquatic habitats (Bryant et al, 1998). The karst-dominated aquatic habitats support a higher biodiversity than the noncarbonate-based systems, have higher growth rates for smolts and resident fish, reflect less variable water temperatures and flow regimes, and contain unique habitat affecting species distribution, abundance, and adaptations (Bryant et al, 1998, Baichtal and Swanston, 1996).

COMMENT

Page 3-103, DEIS: Include discussion and citation of literature regarding potential changes to windfirmness due to thinning in the RMA.

RESPONSE

Windthrow risk will be evaluated when prescribing thinning and openings treatments in RMA to minimize accelerated windthrow. In order to protect the RMA, a Reasonable Assurance of Windfirmness (RAW) zone adjacent to the RMA buffer will be established in situations where multiple high risk factors are present. The RAW buffer guidance document (Landwehr 2007) and Harris 1989 are used to provide guidance when establishing these buffers during planning and final layout. RAW buffers have and continue to be monitored to help determine stability of current practices. Although the monitoring does not yet include young growth, the overall information is relevant as conditions that influence stability are determined through the monitoring process. Monitoring information provided in this section of Chapter 3 is specific to old growth. We have not been monitoring windfirmness of young growth RMA buffers to date. Additional text, including the paragraph below, has been added to Fish section 3.6.

COMMENT

Page 3-103, DEIS: Include discussion and citation of literature regarding how a reduction of the RMA width could affect wood recruitment where average tree heights exceed 100 ft.

RESPONSE

See response for FISH-5. Wood recruitment should not be impacted from thinning as that would be counter to the objectives for RMA. A watershed analysis (as described in Forest Plan Appendix C) would be needed for implementing any alternative that proposed to enter the RMA. Additional information was added to the requested section discussing effect of tree height on LWD addition.

COMMENT

Page 3-118, paragraph 5, DEIS: Consider strengthening the discussion by citing recent research on rainbow trout and steelhead Onchorhynchus mykiss (Kendall et al. 2015, Pearse et al. 2009, Sloat and Reeves 2014a, Sloat and Reeves 2014b).

RESPONSE

The suggested references have been added to the FEIS in the Fish section in Chapter 3.

COMMENT

Page 3-123, DEIS: Please clarify the circumstances where substantially more RMA group selection could occur, and how many acres would be acceptable under this alternative given the standards and management approaches in the riparian section of Chapter 5.

RESPONSE

It would be a rare circumstance that 10-acre openings in RMA would meet the desired future condition for the RMA outside of the TTRA buffer. In most cases, we would envision less than that. The young growth standard for riparian S-YG-RIP-01 allows up to 10 acre openings and up to 35 percent of the acres of the original harvested stand. The management approach for riparian also states that the intent is that young-growth treatments in the RMA must meet the objectives of RMA process groups as defined in Appendix D. Young-growth treatments in the RMA must be consistent with the all of the applicable plan components. Some text changes were made to the Fish section 3.6 to clarify this.

COMMENT

Page 3-126, paragraph 2, DEIS: Consider removing the statement:

Some negative effects, or more appropriately, increased risk, to the natural range of variation in stream processes and fish habitat would likely occur by management activities over the long term for all alternatives. The extent of harvest activity and associated road development are likely to result in decreases of some fish populations in managed watersheds.

This is speculative and contradictory to the statement in the first two sentences of the third paragraph page 3-126. The presence of risk should not be confused or used interchangeably with negative effects, in the absence of supportive research. We recommend removing the association between risk and negative effects to fish habitat from the DEIS. The concept that risk is both normal and being fully mitigated in the Tongass should be added to the DEIS with discussion of Dr. Doug Martin's body of research, cited elsewhere in the DEIS.

RESPONSE

This statement has been removed from the FEIS.

COMMENT

Page D-19, Table 8 DEIS: Consider adding a row in the table showing projected young-growth acreage suitable for harvest in development LUDs following proposed changes to the scenic integrity standards and guidelines and the application of the rules surrounding harvest prior to the culmination of mean annual increment. This would provide perspective when evaluating the necessity to conduct harvest in environmentally sensitive areas by showing the relative gains in available timber from all components of each alternative.

RESPONSE

The relaxed SIOs do not affect the total amount of young-growth that is harvested. They only affect where it is harvested and may also result in larger harvest units in some areas. For example, a higher SIO might force unit openings to be less than 10 or 20 ac but relaxing the SIO may allow them to be 40 or more acres; however, the maximum total acres of young-growth harvested would not change. Therefore, no changes were made to DEIS Table 8 (Table 9 in the Final EIS).COMMENT

Page D-12, paragraph 3, DEIS: Improve clarity by beginning the first sentence with of the action alternatives.

RESPONSE

The statement has been revised.

COMMENT

Page D-12, paragraph 3, DEIS: Consider revising the statement in the last sentence about effects being short-term and localized, which contradicts the statement on page D-11, paragraph 4.

RESPONSE

The statement has been revised.

COMMENT

Page 3-98, Table 3.6-2, DEIS: Suggest changing the title to commonly targeted sport, subsistence, and commercial fish. The existing title is misleading since sport fishing for steelhead in the region is primarily catch-and-release.

RESPONSE

The title has been revised.

COMMENT

3-104, paragraph 1, DEIS: Specify the harvest type discussed in the second sentence.

RESPONSE

The harvest type has been revised. Text was added to clarify that cited evaluation was related to watershed level timber harvest rate.

COMMENT

Page 3-108, paragraph 2, DEIS: Angler days (Table 1), recorded in ADF&G's statewide harvest survey data, better represent fishing effort trends than license sales. The data is available at: http://www.adfg.alaska.gov/sf/sportfishingsurvey/index.cfm?ADFG=region.home.

Table 1.–Angler days by water type among Southeast Alaska communities, 1996–2014

Year	Freshwater	Saltwater	Total
1996	72,459	297,960	370,419
1997	93,478	346,320	439,798
1998	75,445	295,302	370,747
1999	99,054	435,610	534,664
2000	106,355	435,052	541,407
2001	98,093	409,148	507,241
2002	101,563	367,739	469,302
2003	107,755	369,437	477,192
2004	104,166	443,083	547,249
2005	102,200	465,584	567,784
2006	104,834	412,001	516,835
2007	104,431	435,859	540,290
2008	100,094	409,503	509,597
2009	96,343	403,738	500,081
2010	87,279	356,572	443,851
2011	95,332	352,276	447,608
2012	91,009	387,998	479,007
2013	83,871	462,179	546,050
2014	95,068	469,242	564,310

RESPONSE

Information from the total angler effort was added to the text

COMMENT

Page 3-328, Table 3.15-7, footnote 6, DEIS: Please include the data source for the ADF&G ratings.

RESPONSE

As discussed in the Draft EIS (p. 3-327), the data presented in Table 3.15-7 are from the 1997 Forest Plan EIS:

> The Forest Service developed this rating system in response to public comments received on the 1990 DEIS. Recreation places may be important for one, several, or none of the identified categories. Important recreation places by category are summarized in Table 3.15-7 and discussed

further in the *Recreation and Tourism* section of the 1997 Forest Plan Revision FEIS (USDA Forest Service 1997a, pp. 3-109, 3-111).

These same pages are the source of the information presented in Table 3.15-7, including the ADF&G ratings.

COMMENT

Page 3-343, Fishing, DEIS: Please provide a citation for the statement 13 percent of inventoried recreation places acres are currently important for fishing.

RESPONSE

This is a reference to the data in Table 3.15-7. The text has been revised in the Final EIS and now refers the reader back to that table. As noted in response to the above comment, the recreation place rating system was developed as part of the 1997 Forest Plan Revision EIS.

COMMENT

SPEC-25: Specific Fish-related Comments on the Proposed Plan.

Page 5-8, S-YG-BEACH-03, Proposed Plan: In some locations, such as estuaries, the forest edge could be greater than 200 feet from mean high tide and it is not clear whether or not this buffer includes non-forest acreage. If the standard is intended to include non-forested acreage, please include in the FEIS an evaluation of compatibility with the proposed desired conditions of the beach and estuary fringe in Chapter 5 and the forest side standards and guidelines in Chapter 4. If the standard is intended to include forested acreage only, we suggest modifying the first sentence of the standard to *Commercial harvest in the beach fringe is not allowed within a minimum 200-foot buffer beginning at the forested edge above the mean high tide line.*

RESPONSE

S-YG-BEACH-03 now reads: "Commercial harvest within the beach and estuary fringe is not allowed within a minimum 200-foot forested buffer beginning at mean high tide (that is, a no commercial harvest buffer). This does not preclude wildlife enhancement projects and providing access to timber harvest units as long as process group objectives can be met in the RMA.

The management approach for beach and estuary fringe explains that Forest Plan Appendix D provides guidance for delineating RMAs associated with estuarine stream process group. Estuarine RMAs extend 1,000 feet from the landward extent of salt tolerant vegetation, regardless of vegetation type.

COMMENT

Page 5-9, Proposed Plan: A 10-acre opening in the RMA outside of the Tongass Timber Reform Act buffer appears contradictory with desired condition DC-YG-RIP-01, the fish and riparian standards and guidelines of Chapter 4, and Appendix D. Given the desired condition in DC-YG-RIP-01 is to improve functions for soil, water, fish, wildlife, and other resources, while also providing a commercial byproduct, please explain where a 10-acre opening would improve conditions and be approved at the project level, especially if there is no requirement to thin the RMA following harvest. If the assumption in Alternative 5 is that timber can be harvested in such a matter from the RMA, the FEIS should describe instances when a 10-acre opening in the RMA could be implemented so that decision makers understand whether or not this wood source is a reliable element of the alternative.

RESPONSE

It would be a rare circumstance that 10 acre openings in a RMA would meet the desired future condition for the RMA outside of the TTRA buffer. The Alternative 5 standard S-YG-RIP-01 allows up to 10 acre openings and up to 35 percent of the acres of the original harvested stand, and the management approach for riparian states that it is expected that young-growth treatments in the RMA achieve stream

process group objectives as defined in Appendix D of the Forest Plan. Young-growth treatments in the RMA must be consistent with the all of the applicable plan components.

COMMENT

Page 5-9, Proposed Plan: Alternatives 2 and 5 allow removing up to 35% basal area of a stand in the RMA. Consider adding a standard in the Chapter 5 riparian section to clarify how the 35% removal can be distributed across the stand and if harvest can be focused in the RMA.

RESPONSE

Alternative 2 allows for commercial thinning of up to 33 percent of stand basal area. Alternative 5 allows up to 10 acre patch cuts and commercial thinning totaling no more than 35 percent of the total stand acres. A combination of the two treatments may be used, with no more than 35 percent of the total stand removed, as long as the treatment facilitates a more rapid recovery of the late successional forest characteristics.

COMMENT

Page 4-10, Section III, Proposed Plan: Add a reference for the 2015 *Fish Stream Identification and Stream Classification on the Tongass National Forest* document and its associated field guide, which include results of recent working groups and field verification studies.

RESPONSE

The suggested reference was added.

COMMENT

Page 5-7, paragraph 5, Proposed Plan: Consider including prioritization of stewardship fund use on the district where they were generated, a process made easier by Public Law 108-148-DEC.

RESPONSE

The young-growth management approach that discusses using the stewardship authority, where appropriate is based on final recommendations from the Tongass Advisory Committee, which did not address prioritizing the use of stewardship funds. Therefore, this suggestion is not included.

COMMENT

SPEC-26: Specific Subsistence-related Comments on the DEIS.

Pages 3-97 through 3-101, DEIS: This section includes a general characterization of the magnitude of sport and commercial fish harvests from Conrad and Gray (2014). The FEIS should include similar information for subsistence harvest presented in Conrad and Gray (2014).

RESPONSE

Additional information has been added to Chapter 3 of the FEIS in the Fish section.

COMMENT

Page 3-390, first paragraph under abundance and distribution, DEIS: The ADF&G (2014) citation is inaccurate. Please cite the 1987 Tongass resource use cooperative survey (TRUCS), which provides the only survey data for Tenakee Springs and Skagway.

RESPONSE

This has been re-worded in the FEIS.

COMMENT

Pages 3-533 through 3-635, DEIS: In the subsistence sections of the Elfin Cove, Gustavus, Meyer's Chuck, Metlakatla, Pelican, Port Alexander, Skagway, and Tenakee Springs individual community assessments, the 1987 ADF&G harvest data are referenced as distinct from the TRUCS data presented in Kruse and Frazier (1988), but the information in both references is from the same study. Citations in these sections presenting the data from both publications should be reconciled.

RESPONSE

The subsistence discussions for each community draw upon several sources of information including Kruse and Frazier (1988) and the latest information available in the ADF&G Community Subsistence Information System, cited in the EIS as ADF&G (2014). In some cases, as indicated in the comment, the most current information in the ADF&G database is from 1987 and was originally reported in Kruse and Frazier (1988). The references to ADF&G (2014) for the above communities have been deleted to avoid duplication.

COMMENT

Page 3-508, third paragraph, DEIS: Prince of Wales communities are listed as using a combination of hydroelectric and diesel-generated power while the individual community summaries indicate power is generated by diesel only. Please clarify.

RESPONSE

The FEIS has been updated to state that Coffman Cove is served by diesel generation. The other six POW communities identified (Craig, Hollis, Hydaburg, Kasaan, Klawock, and Thorne Bay) are served by hydroelectric generation, with diesel generation used as a back-up. The source of information for the clarification is Black & Veatch. 2012. Southeast Alaska Integrated Resource Plan. Volume 2 – Technical Report. Prepared for the Alaska Energy Authority.

COMMENT

Pages 3-513 through 3-654, DEIS: Please include a citation for the source of information presented in the community use area maps for all communities. If maps are based on the 1987 TRUCS harvest data, please include an analysis of how uses may have changed in the last 30 years.

RESPONSE

The community use areas used in the analysis were originally developed as part of the 1997 Forest Plan revision EIS. The community analysis and the use of these maps is discussed further at the beginning of the Communities section in the subsection entitled Community Assessments. Updated subsistence information is provided for each community based on the most current information available from ADF&G and potential effects to deer are assessed at the WAA level using detailed unpublished information provided by ADF&G. The WAAs analyzed for each community were identified based on the data provided by ADF&G for 2004 through 2013, the most recent available at the time of preparation.

COMMENT

Pages 3-542 through 3-43 and 3-560 through 3-561, DEIS: The Haines and Hyder individual community assessments focus on potential impacts to local resident deer harvests, however, moose are more important for these residents, unlike most other southeast communities. Please modify the assessments to include the importance of moose in these communities.

RESPONSE

Chapter 3 of the DEIS on page 3-509 (subregional overview), states that deer is the only subsistence resource that is potentially significantly affected by the alternatives and that the subsistence analysis therefore uses deer as a key indicator for potential community impacts.

The FEIS has been updated to acknowledge that moose are more important than deer for Haines residents and that moose are not expected to be adversely impacted by any alternative.

Chapter 3 of the DEIS on page 3-560, acknowledges that bear and moose make up most of the land mammal subsistence for Hyder residents. The FEIS has been updated to include goat as well. These species are not expected to be adversely impacted by any alternative.

COMMENT

Pages 3-568, 3-599, and 3-653, DEIS: The Kake, Pelican, and Yakutat individual community assessments specify several subsistence use areas as most important or very important. Please provide a definition for these subjective terms, or eliminate them.

RESPONSE

The cited text has been revised and the words “most” and “very” have been removed as suggested.

COMMENT

Page 3-550, DEIS: Update this section to include recent completion of the Gartina Falls Hydroelectric facility in Hoonah.

RESPONSE

This project has been updated in Chapter 3 of the FEIS in the Renewable Energy section. Gartina Falls Hydroelectric (P-14066) began operating on August 5, 2015 and the 425kw project provides about a third of Hoonah’s energy needs. This information was also updated in the Communities section.

COMMENT

Page 3-604, DEIS: In the Petersburg Subsistence section, replace land mammals (mostly deer) with deer, to be consistent with information for other communities regarding the TRUCS data.

RESPONSE

The words, “land mammals (mostly deer)” has been replaced with “deer.”

COMMENT

Page 3-612, first paragraph: Replace Pelican with Port Alexander.

RESPONSE

Change has been made in the FEIS.

COMMENT

SPEC-27: Specific Plan Comments for Chapters 1 and 2 of the Forest Plan.

Chapter 1 Introduction

Proposed Plan page 1-5 second to last paragraph states: “The communities of Southeast Alaska depend on the Tongass National Forest in various ways, including employment in wood products, commercial fishing and fish processing, recreation, tourism, and mining, and mineral development.” The paragraph also goes on to explain the importance of subsistence resources; however, overlooked is the importance of public access to the forest by all modes including maintenance of forest roads. We recommend

including in the introduction a sentence describing the importance and role of public access and transportation infrastructure.

RESPONSE

The following introductory sentence has been added:

National Forest System roads are a vital component of the State of Alaska's Southeast Transportation Plan to provide for mobility residents, goods and services that facilitates the economic development and sustainability of southeast Alaska. These roads provide access for sustainable resource management as well as recreation opportunities, subsistence use, and community connectivity throughout the islands of the Alexander Archipelago.

COMMENT

Chapter 2 Goals and Objectives

No mention is made under Forest Desired Conditions of transportation utility system goals and objectives.

Recommend the inclusion statements of desired conditions for development and maintenance of regional and area transportation - utility systems:

> Provision and maintenance of air and marine access points and associated infrastructure by the Forest Service, including a system of forest trails and road to facilitate access to forest areas managed for timber harvest and various multi-uses including recreation, subsistence and administration of the forest.
>
> A State of Alaska maintained multi-modal regional transportation system of airports, marine docks and floats, and road system supporting access to and through the National Forest providing efficient and essential transportation between communities within the forest and between the forest and the rest of the world in support of the area economy.

Under Forest-wide Multiple-use Goals and Objectives recommend the addition of the above as goals under a category referred to as "Access." Similar access objectives should be listed under and in support of the following categories:

> Local and Regional Economies
>
> Minerals and Geology
>
> Recreation and Tourism
>
> Renewable Energy
>
> Subsistence and
>
> Timber

Recommend redefining "Transportation" as a category supporting the following Goal:

> Development and operation of transportation and utility infrastructure within the "Transportation Utility System" corridors linking the communities of Southeast Alaska as provided by Section 4407 of P.L. 109-59, as amended by P.L. 114-94, and as allowable under ANILCA Title XI.

RESPONSE

Changes to Chapters 2, 3, and 4 of the Forest Plan were minimized during this amendment. Direction related to the purpose and need of the amendment (young growth, renewable energy, transportation systems corridors) was provided. Therefore, the suggestion to change terms in Chapter 2 was not included.

COMMENT

SPEC-28: Specific Comments for Chapter 3 Management Prescriptions.

Do not replace the overlay Transportation Utility System (TUS) overlay Land Use Designations (LUD) as described in the 2008 Forest Plan. Retention of the TUS LUD is needed to physically locate TUS corridors established by law, replete with goals and management prescriptions having precedence over the underlying LUDs.

RESPONSE

See response to TUS-1.

COMMENT

LUD Management Prescriptions:

ADD TUS LUD overlay LEVEL ONE precedence to other LUDs in the following categories:

SPECIAL INTEREST AREA LUD under TRANSPORTATION, Transportation Operations,

TRAN, add:

B. Coordinate interpretation of the unique values of the Special Interest Area with management of transportation infrastructure in TUS LUD corridors and the rights-of-way of other publicly- owned roadways.

REMOTE RECREATION LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

A. (revise) New roads are not permitted, except within a TUS LUD and to access authorized mineral operations (or as excepted under Lands).

MUNICIPAL WATERSHED LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

A. (revise last sentence) New road construction is generally inconsistent with Old-growth Habitat LUD objectives, but new roads may be constructed if within a TUS LUD. Forest roads may occur in this area with due consideration for protection of the watershed.

OLD-GROWTH HABITAT LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

A. (revise) New road construction is generally inconsistent with Old-growth Habitat LUD objectives, but new roads may be constructed if within a TUS LUD, or if a forest road with no feasible alternative.

B. Add: 4. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

SEMI-REMOTE RECREATION LUD under TRANSPORTATION, Transportation

Operations, TRAN, add:

A. (revise) Where Semi-Primitive Motorized recreation opportunities are emphasized, existing low standard roads are generally managed for use by high clearance or OHVs, snowmobiles, or motorcycles subject to an approved Access and Travel Management Plan. Generally, new roads are not constructed in this area, except within a TUS LUD and to link existing roads or provide access to adjacent LUDs.

Add : 4. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

LUD II Page 3-68 under Objectives add bullet: Roads and utility lines are allowed within a TUS

LUD.

Page 3-72 under Transportation Operations: TRAN: add 3. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

WILD RIVER LUD page 3-74 add under Objectives: Permit road and utility lines allowed within a TUS LUD.

Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-80 (add) D. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

SCENIC RIVER LUD page 3-87 TRANSPORTATION, Transportation Operations: TRAN Add: 5. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

RECREATIONAL RIVER LUD page 3-87 TRANSPORTATION, Transportation Operations: TRAN

Page 3-94 add: 3. Roads and utility lines allowed under a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

EXPERIMENTAL FOREST LUD page 3-100 TRANSPORTATION, Transportation

Operations: TRAN

Add: C. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

SCENIC VIEWSHED LUD

Add under Objectives page 3-101: Roads and utility lines are allowed under a TUS LUD.

TRANSPORTATION, Transportation operations: TRAN, page 3-108

Add: 6. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

MODIFIED LANDSCAPE LUD page 3-109 add under Objectives: Roads and utility lines allowed within a TUS LUD.

Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-115 (add) 6. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

TIMBER PRODUCTION LUD page 3-116 add under Objectives: Roads and utility lines allowed within a TUS LUD.

Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-122 (add) 5. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

MINERALS LUD page 3-123 add under Objectives: Roads and utility lines allowed within a TUS LUD.

Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-128 (add) E. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

RESPONSE

See response to TUS-1 and TUS-2. All of the suggested changes assume the Transportation and Utilities System (TUS) overlay LUD is not removed. Under the Forest Plan, the TUS overlay LUD was removed, as well as all associated direction (i.e., "window" and "avoidance area") in the LUD Standards and Guidelines pertaining to application of this overlay LUD. The TUS LUD management prescription is replaced by plan components in Chapter 5 that provide management direction for renewable energy and transportation systems corridors and is applied to the 17 LUDs in Chapter 3 of the Forest Plan.

See also response to PLR-1.

COMMENT

SPEC-29: Specific comment for Chapter 4 Standards and Guidelines.

Reinstate standards and guidelines for the overlay Transportation Utility System (TUS) Land Use Designations (LUD) as described in the 2008 Forest Plan with corridor goals and management prescriptions having precedence over the underlying LUDs.

RESPONSE

See response to TUS-1 and TUS-2. The Transportation and Utilities System (TUS) overlay LUD was removed, as well as all associated direction (i.e., "window" and "avoidance area") in the LUD Standards and Guidelines pertaining to application of this overlay LUD. The TUS LUD management prescription is replaced by plan components in Chapter 5 that provide management direction for renewable energy and transportation systems corridors and are applied to the 17 LUDs.

COMMENT

SPEC-30: Specific comment for Chapter 5 Plan Content Developed Under the 2012 Planning rule.

Revise the Transportation System Corridor (TSC) to apply solely to development and maintenance of forest roads located outside of the TUS LUD corridors or under the jurisdiction of the U.S. Forest Service.

RESPONSE

See response to TUS-1 and TUS-3. The management direction for transportation systems corridors in Chapter 5 is to facilitate the availability of National Forest System land for the development of existing and future transportation systems such as those identified by the State of Alaska in the current version of the Southeast Alaska Transportation Plan (SATP) and applicable laws (for example, Section 4407 of P.L. 109-59, Title XI of the Alaska National Interest Lands Conservation Act, P.L. 96-487). (See DEIS Chapter 3, Transportation section.)

COMMENT

SPEC-31: Specific comment for Appendices A – K of the Forest Plan.

No appendix on transportation was developed or included. With a proposed major revision, such as the elimination of LUD, it would be helpful to review the analysis and decision-making that supports the major federal action.

RESPONSE

See response to TUS-1. Removal of the Transportation and Utilities System (TUS) overlay LUD was explained in the DEIS in Chapter 3, Transportation section. An analysis of Transportation System Corridor direction has been provided in the EIS.

See also response to PLR-1.

COMMENT

SPEC-32: Page-specific comment for Chapter 3 of the Forest Plan.

Page 3-10, Proposed Plan: We support the proposed decision to reference Title XI of the Alaska National Interest Lands Conservation Act (ANILCA) in the Wilderness LUD Standards and Guidelines. This change will ensure that the full context and process required in ANILCA is considered and followed when transportation and utility projects are proposed within conservation system units designated by ANILCA on the Tongass National Forest (i.e. designated Wilderness).

RESPONSE

Comment noted.

COMMENT

SPEC-33: Retain "adequate and feasible access for economic and other purposes" as it is the correct standard used for inholdings "effectively surrounded" by conservation system units (i.e. designated wilderness) in ANILCA section 1110(b). "Reasonable access" is the standard in ANILCA section 1323, which applies to general national forest lands; not designated wilderness.

RESPONSE

No change required. Adequate and feasible access for economic and other purposes in non-wilderness national monuments must be consistent with the Alaska National Interest Conservation Act of 1980 (ANILCA). The language included in the Forest Plan in TRAN (D) on p. 3-26 of the Proposed Forest Plan refers the reader to the wilderness LUD description. Management direction for Wilderness is included in Chapter 3 for Wilderness and National Monument Wilderness (Proposed Forest Plan, P. 3-19) and for Non-wilderness National Monument (Proposed Forest Plan, P. 3-29) where allowed by ANILCA.

COMMENT

SPEC-34: Plan direction in Chapter 3 should be changed related to rivers found eligible and suitable for inclusion in the Wild and Scenic River System in the 1997 Tongass Land Management Plan.

RESPONSE

See response to WSR-1.

COMMENT

SPEC-35: Page-specific comments for Chapter 4 of the Forest Plan.

Page 4-10, Chapter 4, Proposed Plan: Fish Habitat Planning, Fish Habitat and Channel Processes, part 3: ANILCA section 1326(b) expressly prohibits further studies for the single purpose of considering the establishment of a conservation system unit, which includes Wild and Scenic Rivers, unless authorized by ANILCA or a further act of Congress. Consideration of new wilderness or wild and scenic rivers in this context is inappropriate and we request the following revision:

> Consider topics such as erosion processes, watershed hydrology, vegetation, stream channel morphology, water quality, ~~wilderness designation, recommendations for inclusion into the Wild and Scenic River System~~, species and habitats, and human uses, during analyses.

RESPONSE

The requested change is outside of the scope of this amendment.

COMMENT

Page 4-31, Proposed Plan: III. Temporary Facilities. ANILCA section 1316 applies to all federal public lands where the taking of fish and wildlife is authorized but it does not differentiate between subsistence and non-subsistence use. We request the Service consider whether the distinction in this section is necessary or appropriate.

RESPONSE

The requested change is outside of the scope of this amendment.

COMMENT

Page 4-44, Proposed Plan: Chapter 4 Recreation Resource Planning: The following guideline appears to be relevant to ensuring safe access to communities and popular recreation areas. It is unclear why it is being removed. We request the Service re-consider and provide rationale if it is not retained in the final plan.

> *Support a system of anchorages suitable for recreation boats along small boat waterways that connect communities or provide access to popular recreation attractions.*

RESPONSE

This guideline will be retained in the 2016 Forest Plan in Chapter 4 under Recreation Resource Planning: REC2.

COMMENT

SPEC-36: Page-specific Comments for Chapter 3 of the DEIS.

Page 3-382, third paragraph, DEIS: We request the following edit for clarity and consistency with ANILCA sections 802 and 804:

> *It also states, in part, that "~~customary and traditional~~" subsistence uses of renewable resources "shall be the priority consumptive uses of all such resources on the public lands of Alaska when it is necessary to restrict take."*

RESPONSE

The requested change has been made in the Subsistence section.

COMMENT

Page 3-382, fourth paragraph, DEIS: We request the following edit for accuracy:

> This ruling took the state out of compliance with ANILCA and the federal government has managed harvest of subsistence resource s under federal subsistence regulations on federal lands in Alaska since 1990. As a result, federal subsistence harvests of fish and wildlife on the Tongass National Forest are presently managed by the Forest Service (Schroeder and Mazza 2005).

RESPONSE

This requested change was not made, but is very minor.

SPEC-37: Page-specific Comments for Climate and Air section of the DEIS from ADEC (SOA-034)

COMMENT

Page 3-16, paragraph three, sentence one, should read: "The State of Alaska Department of Environmental Conservation (ADEC) under the Clean Air Act (CAA), via Title I and Title 5 of the EPA approved State Implementation Plan (SIP) regulates air emissions from stationary sources."

RESPONSE

Comments from Alaska Department of Environmental Conservation provided clarifying language within the Climate and Air section of Chapter 3.1 found on pates 3-16, 3-18 and 3-19 of the DEIS. These clarifications have been incorporated into the FEIS.

COMMENT

Page 3-18, paragraph three, sentence seven, notes that " In an effort to better address the air quality concerns in the Wilderness, the Forest Service and ADEC enters into a Memorandum of Understanding each year to train Forest Service wilderness rangers to visually monitor cruise ship emissions with EPA-approved standards." This sentence should be updated to reflect that the MOU is static and does not get entered into each year.

RESPONSE

The sentence has been clarified as follows:
In an effort to better address the **visibility** concerns in the Wilderness **due to cruise ship smoke**, the Forest Service and ADEC **have developed** a Memorandum of Understanding to train Forest Service wilderness rangers to visually monitor cruise ship emissions with EPA-approved standards."

COMMENT

Page 3-19 paragraph one, sentence three, should read: "EPA and ADEC have limited regulatory responsibility, under the Clean Air Act, for air quality related to these kind of sources." This sentence was discussing indirect sources such as firewood burning and vehicle emissions.

RESPONSE

This sentence has been clarified as recommended.

COMMENT

Page 3-22, paragraph two, sentence five refers to "shrinking alpine habitats." This may need to be re-examined and perhaps changed to read "changing alpine habitats" to reflect the fact that glacier melting may expose new alpine habitat at a quicker rate than those of altitudinal forest shifts.

RESPONSE

Melting glaciers do not expose new alpine habitat but rather "new non-forested habitat" that quickly becomes vegetated. Some lateral edges of glaciers as they shrink may uncover "alpine" habitat as the ice may be of higher elevation, but the terminus of many glaciers is not alpine, but sea level. We clarified to read "**changing non-forested** habitats" Altitudinal forest shifts means the marching of shrubs and trees up in elevation. We do not have information as to which is faster, retreating glacier re-vegetation, or the shifting of the true alpine zonation.

COMMENT

SPEC-38: Page-specific Comments for Water section of the DEIS from ADEC.

Page 3-56, paragraph three, sentence two should read: "*Turbidity criteria indicate values will not exceed 5 nephelometric turbidity unites (NTUs) over natural conditions, when* ***natural*** *values are less than 50 NTUs.*" The original text used the word "nature".

Page 3-68, paragraph five, sentence two should read: “Landslide debris (e.g., sediment, large wood) that enters the stream may block or shift channels, fill pools, and **increase the presence of fine sediments** in the channel network.” The original text used the words “increases fines presences” which is grammatically cumbersome.

RESPONSE

Edits have been made.

COMMENT

SPEC-39: Page-specific comments on Appendix G of the DEIS from ADEC.

Appendix G, page G-11, M4(c) should be revised to read *“Measurements required by M4; a and b are from MHW (Mean High Water) to depths of **100** feet MLLW (Mean Lower Low Water).”*

RESPONSE

No justification was provided for making this change from 60 feet to 100 feet. The discussion on page G-11 under M4 reads, “Sixty feet below MLLW was selected because it is a depth at which repeated dives can safely be conducted.” No change was made.

COMMENT

SPEC-40: Typos for Appendixes of the DEIS from ADEC.

COMMENT

Draft EIS, Page A-1: An incorrect date of “June 23, 2016” is given for publishing the corrected Notice of Intent.

RESPONSE

Corrections have been made in FEIS.

COMMENT

Draft EIS, Page B-18: “Intermeidate” is misspelled.

RESPONSE

Corrections have been made in FEIS.

COMMENT

SPEC-41: Make Plan consistent with the TAC and the Roadless Rule.

To make the plan consistent with the Tongass Advisory Committee (TAC) recommendations and the Roadless Rule, the language regarding these areas should be clarified to ensure that there should be no old-growth sales planned in these areas at any point during the transition or after.

We recommend that the language on page A-4 of the Proposed Plan be changed to better reflect the recommendation of the Tongass Advisory Committee to ensure that all of these places are protected: "*Within Development LUDs, the following old-growth stands (as shown on maps in the planning record) are identified as NOT suitable for timber production: (1) Phases 2 and 3 of the 2008 Forest Plan Timber Sale Program Adaptive Management Strategy; (2) Trout Unlimited T77 watersheds; and (3) The Nature Conservancy/Audubon Priority Conservation Areas.”*

RESPONSE

Corrections have been made in the Forest Plan based on the Final Tongass Advisory Committee recommendations (see Appendix A and B of the Forest Plan).

COMMENT

SPEC-42: In chapter 5, there is a need for an addition of some specific language in the recommendations that should be included in management approaches for young growth.

In chapter 5, there is a need for an addition of some specific language in the recommendations that should be included in management approaches for young growth, as well as included in each section in chapter 5 where management approaches are outlined.

The language that should be included is the language that deals with doing post-project/after- action reviews. There is good language in this section on pre-project collaboration and planning and the TAC recognizes the way the Forest Service has integrated our comments on these concepts. However, the "after project review" was missed which specifically speaks to our intent that young growth projects (especially in the unsuitable lands) will need to go through a period of experimentation and innovation. In order for each project to increase the knowledge of how to do these projects better and learn from what was successful and unsuccessful, after- action reviews will all stakeholders need to be conducted.

Additions:

The following language from the TAC recommendations should be included:

- Working with project collaboratives, prepare pre- and post-project reports to the public about what was planned, what happened with the project or activity. Highlight positive results, such as collaborative planning, restoration, workforce development, jobs, and injection of capital into the economy and identify areas not meeting expected outcomes in order to address options through future efforts
- Design and implement a simple after-action review with project collaborators for the purpose of identifying opportunities to make the projects achieve better outcomes in terms of efficiency and effectiveness. Document and share.

See response to CONS-4.

RESPONSE

Collaborative approaches to engaging the public and assessing the impacts of federal actions under the National Environmental Policy Act (NEPA) can improve the quality of decision-making and increase public trust and confidence in agency decisions, and we believe that this plan provides opportunities to do that. One of the primary goals of NEPA is to encourage meaningful public input and involvement in the process of evaluating the environmental impacts of proposed federal actions. The NEPA process is a public process, and the Forest Service is required to "encourage and facilitate public involvement in decisions which affect the quality of the human environment" (40 CFR 1500.2(d)).

We appreciate these recommendations, but have not included them in the 2016 Forest Plan. The responsible official may identify the need for post-project collaboration as the Forest begins to implement the 2016 Forest Plan. If the responsible official believes that this is needed, management approaches may be addressed through an administrative change to the plan.

COMMENT

SPEC-43: Request for chapter 5 changes regarding high value watersheds.

Proposed Plan, Chapter 5, Plan Content Developed Under the 2012 Planning Rule, page 5-7 (High Value Watersheds)

Current language:

"It is expected that at the end of five years following the signing of the Record of Decision (ROD) for this proposed plan amendment, the Forest Service would conduct a trend analysis on the annual best

management practices (BMPs) monitoring of young-growth timber projects that intersect with the following watersheds…"

Replace with the following:

"It is expected that by the end of the five year period after the signing of the ROD, the Forest Service will conduct an internal scientific review together with the Tongass Transition Collaborative and other stakeholders to determine likely impact to fish and wildlife habitat from proposed young growth timber projects that intersect with the following high-value fish producing watersheds. If harvest is proposed in one of these watersheds, the USFS may apply additional standards or guidelines to mitigate risk to fish habitat, or may apply a "no net-loss" exchange for other areas for young growth harvest."

RESPONSE

Edits were made in the Young Growth Management Approaches in Chapter 5 of the Forest Plan that capture most of this recommendation. The Forest Service also added the following:

> "In addition, it is expected that at the end of five years and ten years following the signing of the ROD for this plan amendment, the Forest Service would conduct monitoring with stakeholders to determine if the young-growth goals are being achieved, and if not, adjust accordingly."

The need for additional standards or guidelines (plan components), other than the plan components that apply to the LUD where project takes place, would be determined through monitoring. A plan amendment is required to add plan components (36 CFR 219.13(a)). Applying a "no net-loss" exchange for other areas for young-growth harvest may be a project-specific mitigation measure.

COMMENT

SPEC-44: Proposed Plan Appendix A – Timber Production Land Suitability, Step 2 – Lands Suited and Not Suited for Timber Production Based on Compatibility with Desired Conditions and Objectives (FSH 1909.12, Section 61.2), Page A – 4, Item 3. B.

Current language:

"Within Development LUDs, old-growth stands in Phases 2 and 3 of the 2008 Forest Plan Timber Sale Program Adaptive Management Strategy, in the Trout Unlimited TU77 watersheds, and in The Nature Conservancy/Audubon Priority Conservation Areas (as shown on maps in the planning record) are identified as NOT suitable for timber production, except for small sales after the transition is complete. Young-growth stands in all of these areas are identified as suitable for timber production."

Replace with the following:

"Within Development LUDs, old-growth stands (as shown on maps in the planning record) in (1) Phases 2 and 3 of the 2008 Forest Plan Timber Sale Program Adaptive Management Strategy, (2) the Trout Unlimited TU77 watersheds, and (3) The Nature Conservancy/Audubon Priority Conservation Areas are identified as NOT suitable for timber production. Young-growth stands in all of these areas are identified as suitable for timber production."

RESPONSE

Edits were made in Appendix A of the Forest Plan.

COMMENT

SPEC-45: The draft TAC recommendations stated, "During the transition period, the annual timber volume target should be held constant. Subject to review of the DEIS, the TAC will recommend a volume target to hold consistent through the transition period." The TAC expected to see an analysis by the Forest Service of the effects of two different annual volume targets. The DEIS did not include an analysis of two volume targets, and the TAC was unable to reach consensus on an annual volume target. The range of annual volumes supported by individual TAC members for

analysis remains at 46MMBF – 70MMBF. We want to be clear that the TAC did not agree to a specific annual target.

RESPONSE

The PNW Research Station's most recent timber demand projections (Daniels et al., 2016) used to inform the EIS analysis include a baseline model and three different scenarios displaying alternative futures for Southeast Alaska. In the baseline model, 46 MMBF represents the annual average timber demand for Tongass timber over the next 15 years – with a range of 41 MMBF to 52 MMBF during the same time period. As the forest plan amendment interdisciplinary team began the amendment process and focused on timber market demand, 46 MMBF was used to inform timber objectives used during the planning process.

The Daniels et al. (2016) study of long-term timber demand projections is based on economic theory, peer-reviewed methodology, and scientific and objective analyses conducted by timber economists and forest researchers. Daniels et al. avoids recommending any one scenario as a "most likely" projection because of the relatively high degree of uncertainty surrounding developments in Southeast Alaska. The baseline model, however, utilizes historical datasets necessary to represent Southeast Alaska timber markets and assumes the timber industry in Southeast Alaska will remain at post-2008 recession levels for the next 15 years. As such, the baseline annual average of 46 MMBF timber demand from the Tongass is considered a conservative and rationale estimate. In addition, the 46 MMBF projection is not only represented in the baseline model, but it is also represented in all three scenarios at different points in time, and these scenarios represent alternative futures for timber harvest in Southeast Alaska.

COMMENT

SPEC-46: In forest-wide objective O-TIM-02 in Chapter 5 of the Forest Plan, clarify the difference between "annual market demand" and "projected timber sale quantity (PTSQ)". Based on the definition of PTSQ, the PTSQ timber volume is not a function of demand. Make two separate objectives to clarify this distinction.

RESPONSE

Forest-wide objective O-TIM-01 was written to be a "concise, measurable, and time-specific" statement to describe the timber outcomes expected. This forest-wide objective has been revised to avoid confusion.

Attachment A
Letters from Agencies, Elected Officials, and Tribal Governments

Date submitted (UTC): 1/31/2016 6:13:23 PM
First name: Rep.
Last name: Josephson
Organization:
Title:
Official Representative/Member Indicator:
Address1:
Address2:
City:
State:
Province/Region:
Zip/Postal Code:
Country:
Email: Rep.Andy.Josephson@akleg.gov
Phone:
Comments:
Tongass National Forest Management Plan (due Feb 22, 2016)

Dear Ms. Howle:

I am not a scientist, a fisheries biologist, a timber man or an expert on forest ecology. I am an armchair observer of Tongass politics and the forest itself. I am a student of public policy and a citizen concerned with our future.

To the extent the following comments can be woven into others and into the USFS?s management plan update, I would appreciate it.

My own beliefs are that:

1) What we are doing as a people is not sustainable. The Earth wasn?t designed to hold $7 billion all vying for scarce resources. Pressures on those resources are being felt every day. Sometimes the wiser mover is the conservative one?conserving a resource. And more than Gifford Pinchot may have foreseen. To the extent possible, leave the Tongass Forest in tact, and alone.

2) Do not sell uncut timber, without value added, to overseas or domestic purchasers.

3) Do not clear cut old growth timber. Lesnoi on Afognak Island has done enough of that, as has SeaAlaska.

4) Tourists and cruise ship customers do not want to see denuded landscapes in SE Alaska. They just don?t.

5) Do not ever let heavy equipment be driven across a salmon stream.

6) Do not ever let trees be denuded right down to salmon banks.

7) Do not decimate the rest of SE the way that Prince of Wales Island has been. I personally told Secty. Vilsack when I met him in the Summer of 2014, that I hoped the USFS lost the litigation related to the Big Thorne harvest. He won, and I lost, apparently.

8) It?s ?o.k.? to say ?no?. It?s ?o.k.?

9) Alaska?s industry is already less than 10% of what it was. Don?t bring it back. The economy has adjusted. Just leave it alone.

10) Future generations will be unimpressed with the amount of wealth and comfort we?ve amassed since the Industrial Revolution. They?ll be more impressed with the natural beauty we protect.

Thanks for listening,

State Rep. Andy Josephson

Juneau, Alaska

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
1689 C Street, Room 119
Anchorage, Alaska 99501-5126

VIA ELECTRONIC MAIL, NO HARD COPY TO FOLLOW

9043.1
ER 15/0644 February 17, 2016
PEP/ANC

Mr. Earl Stewart
Tongass National Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, AK 99901

Subject: Draft Environmental Impact Statement for the Tongass Land and Resources Management Plan Amendment, Alaska

Dear Mr. Stewart:

The U.S. Fish and Wildlife Service (FWS) has participated as a cooperating agency in developing alternatives and providing information for the U.S. Forest Service's (Forest Service) Proposed Land and Resources Management Plan (Forest Plan) amendment for the Tongass National Forest (Tongass) and the associated Draft Environmental Impact Statement (EIS) currently under review. The Department of the Interior (Department) appreciates the opportunity provided to the Department's FWS to serve as a cooperator. Our comments focus on areas of continuing concern and are based on our authorities under the Fish and Wildlife Coordination Act and the National Environmental Policy Act.

General Comments

The Forest Plan amendment is intended to help accelerate transition away from harvest of old-growth forest, in favor of greater reliance on second-growth or "young-growth" forests that have regenerated following timber harvest. The Department fully supports this goal, as it has excellent potential to reduce impacts of the Forest Service's timber program on fish and wildlife. We understand that a secondary purpose of the Forest Plan amendment is to facilitate development of renewable energy on the Tongass.

Old-growth logging on the Tongass has been controversial, in part due to direct and indirect impacts to fish and wildlife caused by clearcut logging and the roads associated with logging. In response to these concerns, the Forest Service developed the Tongass Old-Growth Conservation Strategy (conservation strategy) in partnership with the FWS, the State of Alaska, and others, as part of the 1997 Forest Plan. This conservation strategy features a network of old-growth

reserves (OGR) and other non-development land use designations to protect important habitat and corridors connecting the reserves. The conservation strategy also includes a suite of standards and guidelines that direct how timber harvest and other activities must be conducted to reduce impacts to vulnerable species. The conservation strategy remains an integral part of the current (2008) Forest Plan. The notice of intent (NOI) for the current Draft EIS states, "It is not expected that changes made to the Tongass Forest Plan will affect the overall integrity of the Plan's conservation strategy." We are concerned that some elements of the proposed action, (Draft EIS Alternative 2, p. 2-14) or the Forest Service's preferred alternative (Draft EIS Alternative 5, p. 2-31), could significantly weaken the conservation strategy, conflicting directly with the expectation stated in the NOI.

Below, we provide specific recommendations regarding clearcut logging and extensive commercial thinning without appropriate slash treatments in riparian management areas, beach and estuary fringe, and OGRs. We recommend development and selection of an alternative that avoids sensitive areas and important habitats for any renewable energy or transportation projects approved under the Forest Plan. We also recommend that specific elements of the conservation strategy be updated with the best available scientific data and strengthened by incorporating experience from the last 20 years of management, specifically where available information suggests the current conservation strategy is not adequate to sustain vulnerable species.

Specific Comments

<u>Riparian, Beach and Estuary Fringe, and OGR Logging</u>

Riparian areas have been protected from logging to maintain water quality, streambank stability, and habitat for fish and wildlife across the country for many decades. The Tongass Timber Reform Act (TTRA, H.R. 987) has mandated protection of riparian buffers along fish-bearing streams and many of their tributaries on the Tongass since 1990. The TTRA buffers have been expanded for many channel types where scientific information or management experience showed that additional protection was warranted to minimize impacts from logging. These standards should be relaxed only if reliable scientific evidence clearly demonstrates that the protection is not necessary. Such findings are not presented in the Draft EIS. Also, the Draft EIS contains little evaluation of the consequences of relaxing the existing standards. We recommend the Final EIS include scientific or data-based recommendations supporting proposed management changes and provide a more robust discussion of impacts of proposed changes.

Beach fringe is defined in the Forest Plan as, "the area inland from saltwater shorelines that is typically forested." The current Forest Plan forbids clearcut logging within 1,000 feet of saltwater shorelines to protect habitat for many species of wildlife, including deer, bears, bald eagles, otters, geese, and many others. Both the proposed action and preferred alternative would allow clearcutting and commercial thinning in beach fringe. Large forest openings and extensive timber thinning without appropriate slash treatments can interfere with animal movements and increase vulnerability of some species to predation, harvest by humans, and/or exposure to deep snow and severe weather. We recommend that the selected alternative limit young-growth treatments to actions that maintain or improve wildlife habitat in beach and estuary fringe forest. We also recommend openings be limited to two acres or less in order to maintain hunting habitat for goshawks and provide thermal cover for deer. Moreover, we recommend that slash be

treated to allow unconstrained movement of deer, bears, wolves, and other species. We also recommend against creating openings in beach fringe where a corridor of mature or old forest less than 660 feet wide would be left, in order to maintain effective thermal cover (Concannon 1995).

Similarly, OGRs have been designated specifically to support wildlife dependent on old-growth forest. To achieve maximum conservation benefit, treatments in OGRs should be designed primarily to accelerate development of old-growth characteristics without compromising landscape connectivity and animal movement. For instance, thinning with slash treatment, pruning of lower branches to improve light penetration, small patch cuts, and narrow strip cuts might all be used to treat second-growth in OGRs to accelerate development of old-growth characteristics. We strongly recommend against creating large clearcut openings in OGRs, given the importance of this productive old-growth forest for a variety of species.

Management actions that reduce long-term habitat values (by clearcutting in riparian areas, beach fringe, or OGRs) or disrupt movement of animals through logged landscapes (by cutting in designated corridors such as beach fringe and riparian zones) could undermine the intent and the functioning of the conservation strategy. We recommend against allowing such actions, which we believe seriously compromise the integrity of the conservation strategy.

If inadequate young-growth timber is available to meet demands outside of riparian, beach and estuary fringe, and OGRs, we recommend that additional alternatives be developed to offer only the volume of young-growth that can be produced without impacting these sensitive areas. If necessary, additional old-growth could potentially be offered from areas with lower environmental sensitivity, to offset reductions in young-growth availability. We also recommend that one or more alternatives be developed to evaluate longer timber harvest transition periods, if necessary, to avoid creating large openings in these sensitive habitats.

Renewable Energy and Transportation Systems Corridors

All action alternatives identified in the Draft EIS would remove the Transportation and Utility Systems Overlay land use designation, which identifies “windows” where road and utility corridors are deemed compatible and “avoidance areas” where roads and other human infrastructure would conflict with other resource values. Current guidance would be replaced by direction in the Transportation Systems Corridors section, which is intended to facilitate the availability of Tongass lands for development of transportation systems (Proposed Forest Plan, pp. 5-13 to 5-15). The proposed direction removes constraints on development of roads and utility corridors, while adjusting management of other resources to allow development of these corridors.

We recommend that sensitive habitats be avoided when renewable energy facilities or transportation and utility corridors are proposed, studied, and ultimately developed. We support inclusion of plan components that require siting roads and other infrastructure outside of OGRs, beach fringe, designated wildlife corridors, and other sensitive areas unless an analysis demonstrates that there are no practical alternatives. The action alternatives evaluated in the Draft EIS do not appear to require this analysis, which leads to the presumption that construction of roads and renewable energy facilities are allowed wherever they may be proposed,

irrespective of habitat values. This proposed approach could undermine the integrity of the conservation strategy, which was designed to protect important habitat in specific locations from human impacts.

Updating Plan Components for Wildlife

Alexander Archipelago Wolf

Concerns over documented, unsustainable mortality of wolves on Prince of Wales Island have triggered several reviews, recently resulting in a petition to list the endemic Alexander Archipelago wolf as threatened or endangered under the Endangered Species Act. The latest FWS status assessment (FWS 2015) reviewed the status of the wolf across its range and for several discrete populations. The greatest concern continues to be for wolves on Prince of Wales and surrounding islands. The wolf population there appears to have declined from about 350 wolves in the 1990s and early 2000s to approximately 89 wolves in 2014 (FWS 2015). This decline is believed to be due to the combined effects of both legal and unreported (illegal) harvest of wolves, facilitated by an extensive network of logging roads and declining deer numbers, which in turn are associated with the loss of winter habitat and regeneration of young-growth forests in intensively logged areas. Despite concerns that the wolf population on Prince of Wales has declined and will likely continue to decline, the FWS did not list the wolf as threatened or endangered because loss of the Prince of Wales population is not expected to affect survival or vulnerability of the subspecies across the rest of its range (Federal Register 81(3), pp. 435-458).

Under the Forest Service's 1982 planning rule (47 FR 43037, Sept. 30, 1982), which continues to apply to most of the wildlife standards and guidelines in the proposed Forest Plan, the Tongass must be managed to provide for viable, well-distributed populations of native wildlife. We believe that this includes maintaining the wolf population on Prince of Wales Island. Implementation of existing standards and guidelines intended to protect wolves from unsustainable harvest and habitat loss appears to be inadequate for the wolves on Prince of Wales, given the population's documented decline. For example:

- Management of road densities to limit hunter and trapper access is recommended, but not required by the current standards and guidelines, and most areas on Prince of Wales exceed the recommended 0.7 to 1.0 miles of road per square mile;
- Maintenance of deer habitat capability (as calculated by the interagency deer habitat model) to sustain wolf populations and human hunters appears to be required by the current Forest Plan, but many areas fall short of the specified 18 deer per square mile. Recent timber sales have reduced deer habitat capability further; and
- A wolf habitat management program is to be developed where wolf mortality concerns have been expressed, but no such program has been developed despite repeated expressions of concern by the FWS, the Department, and others, as well as the completion of various interagency studies of wolf mortality.

The Forest Plan amendment process offers an opportunity to strengthen the wolf standards and guidelines to help the Forest Service maintain or increase the amount of secure and high-value habitat required to maintain a viable wolf population on Prince of Wales. We recommend that a

wolf habitat management program be developed, as recommended by the Forest Plan. The FWS can provide assistance in development of this management program.

Additionally, we recommend that road density guidelines be strengthened to require reduction of road densities where wolf harvest mortality exceeds sustainable levels in areas where roads provide access for wolf trapping. We also recommend that no future timber sales be allowed that reduce deer habitat capability in areas where it is already below levels believed to be necessary to support human hunters and wolves.

Queen Charlotte Goshawk

Standards for management of northern goshawk nesting habitat should also be updated to reflect the best available science. Much of the current science on management of goshawk nesting habitat in the coastal rainforests of the North Pacific coast is reviewed in McClaren et al. (2015). We recommend modification of two elements of the Forest Plan to better protect goshawks, which are vulnerable to habitat loss and disturbance from forest management practices.

Goshawks are known to forego nesting in years with low prey abundance and/or inclement spring weather. Nest sites are routinely inactive for a few years, then become active again when conditions are favorable. The current Forest Plan allows nest protections to be dropped after two consecutive years of inactivity. We strongly recommend that this standard be modified to protect documented goshawk nesting stands indefinitely, unless an active nest is detected elsewhere in the same goshawk territory. The FWS has worked with the Forest Service directly to develop suggested language for an updated plan component to accomplish this goal. We recommend that the modified standard be included in the selected alternative.

Fledgling goshawks typically learn to fly and hunt in an area of about 500 acres adjacent to their nest stand. Forest management to maintain suitable hunting habitat in the area around the nest is thought to be important for maintaining productivity of goshawk nesting territories. We therefore recommend that post-fledging areas around known or suspected nest sites be managed to prevent creation of large forest openings, which are avoided by goshawks.

Legacy Forest Structure

The current Forest Plan requires retention of legacy forest structure in old-growth harvest units greater than 20 acres, in areas where logging has been most intensive. The intent of this standard is to ensure that sufficient residual trees, snags, and clumps of trees remain in timber harvest units in watersheds that have had concentrated past timber harvest activity and are at risk for not providing the full range of matrix functions (Proposed Forest Plan, track changes version, p. 4-90). Areas of extensive young-growth, which will support increasingly greater proportions of the Tongass's timber harvest into the future, often lack adequate residual structure.

We strongly recommend that the selected alternative include updated Forest Plan components that restore habitat-related functions provided by older forest structure, where past logging has left large areas of young-growth. Retention of residual old-growth, supplemented by second-growth where inadequate old-growth remains, will help move harvested stands toward a

condition that will support a broader variety of wildlife in the future as retained young-growth stands mature.

Alternatives 3 and 4 in the Draft EIS would apply the existing legacy forest structure standards (designed for old-growth logging) to young-growth harvest (Draft EIS, Appendix F, pp 3-4). The existing standard requires retention of 30 percent of each harvested stand, in watersheds where the standard applies. We believe that a legacy forest structure standard designed specifically for young-growth harvest may not necessarily match existing standards and guidelines designed for old-growth logging. Instead, we recommend that new Forest Plan components consider the amount and distribution of residual old-growth and require retention of additional young-growth as necessary to meet the intent of the standard. This could reduce impacts on young-growth timber volume availability, while providing adequate structure to improve habitat values into the future. We encourage development of guidance on treatments that would accelerate succession of retained young-growth toward old-growth conditions. If retention of structure in young-growth stands would delay the transition to primarily young-growth harvest, we recommend additional alternatives that use a longer transition period be developed and fully evaluated.

Thank you for the opportunity to collaborate as a partner in your effort to amend the Forest Plan. If you have any questions on our comments, please feel free to contact Steve Brockmann, Southeast Alaska Coordinator for the FWS, at 907-780-1181 or at steve_brockmann@fws.gov.

Sincerely,

Philip Johnson, PhD
Regional Environmental Officer

cc: Jackie Timothy, Alaska Department of Fish and Game

Literature Cited

Concannon, J.A. 1995. Characterizing structure, microclimate and decomposition of peatland, beachfront, and newly logged forest edges in southeastern Alaska. PhD Dissertation, Univ of Washington. 325 pp.

McClaren, E.L., T. Mahon, F.I. Doyle, and W.L. Harrower. 2015. Science-based guidelines for managing northern goshawk breeding areas in coastal British Columbia. Journal of Ecosystems and Management 15(2):1-91.

U.S. Fish and Wildlife Service. 2015. Species status assessment for the Alexander Archipelago wolf (*Canis lupus ligoni*). December 2015. Alaska Region, Anchorage, Alaska. 162 pp.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ECOSYSTEMS, TRIBAL
AND PUBLIC AFFAIRS

February 22, 2016

M. Earle Stewart, Supervisor, Tongass National Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, Alaska 99901

Dear Mr. Stewart:

Thank you for the opportunity to review the Draft Environmental Impact Statement for the Tongass Land and Resource Management Plan Amendment, Tongass National Forest, in southeast Alaska (EPA Project #14-0026-AFS). We have reviewed the Draft EIS in accordance with our responsibilities under the National Environmental Policy Act and Section 309 of the Clean Air Act. Specifically Section 309 directs EPA to review and comment in writing on the environmental impacts of major federal agency actions. Our review considered the evaluation of the anticipated environmental impacts, as well as the adequacy of the EIS in meeting procedural and public disclosure requirements of NEPA.

Based on our review, we have assigned the Draft EIS a rating of EC-2 (Environmental Concerns-Insufficient Information). We believe that the most recent, southeast Alaska-specific data and information should be incorporated into the climate and greenhouse gas analyses and discussion in the final EIS. An explanation of our rating system is enclosed (Enclosure 1). In general, we support the selection of the Forest Service and Technical Advisory Committee's preferred alternative, Alternative 5. We believe Alternative 5 meets the direction of Secretarial Memorandum 1044-009 by accelerating the transition to young-growth, while also providing greater flexibility for alternative energy projects, and appropriate review of inventoried roadless areas.

We appreciate the inclusion of a "track changes" version of the 2008 Forest Plan and the scoping and comment summary report (Appendix A) in the Draft EIS. These resources greatly facilitated our review. An Executive Summary would also have been helpful, especially to stakeholders who might not be able to review the full document. We recommend that an Executive Summary be included in the Final EIS.

As we stated in our scoping comments, we support appropriate updates to standards and guidelines that reflect the most recent management science regarding ecological services, climate change and resiliency. We also recognized the need for adequate socioeconomic analysis to promote the sustainability of Southeast Alaska communities, particularly tribal, low income and minority communities, dependent on timber harvesting and other activities on the Tongass. We believe the Tongass Amendment EIS adequately accomplishes this through the thorough analyses and evaluation of management alternatives, resources and projected outcomes and goals. We also appreciate that a broad range of potential activity types, such as communication sites, renewable power projects, and mining, as well as timber harvest were considered in this programmatic document. We believe doing so allows for greater disclosure to and participation of stakeholders, potential permittees and forest users.

Finally, we have recommendations for your consideration in the area of climate change and greenhouse gas emissions in the Final EIS. We appreciate the thorough discussion in the Draft EIS of the various factors that affect and drive climate in southeast Alaska. We also recognize that, in addition to the USDA Secretarial Memorandum 1044-009, another primary driver for undertaking this Forest Plan amendment is to consider changes in forest management and health as a consequence of a changing climate.

We believe the Affected Environment section contains adequate discussion of climate inputs and possible anthropogenic effects on climate. We recommend, however, that the most recent sources of data for Alaska be used wherever possible. For example, our own Climate Impacts in Alaska website (http://www3.epa.gov/climatechange/impacts/alaska.html) references the 2014 National Climate Assessment (http://nca2014.globalchange.gov/report/regions/alaska#intro-section), which states Alaska temperatures have increased approximately 3 degrees F in the last 60 years. Also, current data from The Alaska Climate Research Center indicates that while total mean seasonal and annual temperatures in Alaska from 1959 to 2014 reflect an increase in temperature, temperatures from 1979 to 2014 generally show a decline in mean seasonal and annual temperatures (http://akclimate.org/ClimTrends/Change/TempChange.html) in most of Alaska, including southeast Alaska. This trend, along with increased ice extent in the Bering Sea, differs from trends identified in the Arctic, such as increased temperatures and decreased overall Arctic ice extent. We believe assessment of climate change for the Tongass should be as specific to southeast Alaska as practicable.

The Final EIS might also consider the following additional factors for incorporation into the relevant air quality and climate change sections of the main document, or as an appendix. These include quantification of GHG emissions from the proposed action and appropriate quantitative or qualitative analytical methods to ensure useful information is available to inform the public and the decision-making process in distinguishing between alternatives and mitigations.

Thank you again for the opportunity to review the Draft Environmental Impact Statement for the Tongass Land and Resource Management Plan Amendment. Please contact Jennifer Curtis of my staff in Anchorage at 907-271-6324 or curtis.jennifer@epa.gov with any questions you may have.

Sincerely,

Christine B. Littleton

Christine B. Littleton, Manager
Environmental Review and Sediments Management Unit

Enclosure:
1. U.S. Environmental Protection Agency Rating System For Draft Environmental Impact Statements

Date submitted (UTC): 2/22/2016 12:00:00 AM
First name: Christine B.
Last name: Littleton
Organization: United States Environmental Protection Agency, Region 10
Title: Office of Ecysystems, Tribal and Public Affairs
Official Representative/Member Indicator:
Address1: 1200 Sixth Avenue, Suite 900
Address2:
City: Seattle
State: WA
Province/Region:
Zip/Postal Code: 98101-3140
Country: United States
Email: curtis.jennifer@epa.gov
Phone: 907-271-6324
Comments:
February 22, 2016

M. Earle Stewart, Supervisor, Tongass National Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, Alaska 99901

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Thank you again for the opportunity to review the Draft Environmental Impact Statement for the Tongass Land and Resource Management Plan Amendment. Please contact Jennifer Curtis of my staff in Anchorage at 907-271-6324 or curtis.jennifer@epa.gov with any questions you may have.

Christine B. Littleton, Manager
Environmental Review and Sediments Management Unit

Enclosure:
1. U.S. Environmental Protection Agency Rating System For Draft Environmental Impact Statements

U.S. Environmental Protection Agency Rating System for
Draft Environmental Impact Statements
Definitions and Follow-Up Action*

Environmental Impact of the Action

LO – Lack of Objections

The U.S. Environmental Protection Agency (EPA) review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC – Environmental Concerns

EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce these impacts.

EO – Environmental Objections

EPA review has identified significant environmental impacts that should be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no-action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EU – Environmentally Unsatisfactory

EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the Council on Environmental Quality (CEQ).

Adequacy of the Impact Statement

Category 1 – Adequate

EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis of data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2 – Insufficient Information

The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses or discussion should be included in the final EIS.

Category 3 – Inadequate

EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the National Environmental Policy Act and or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

* From EPA Manual 1640 Policy and Procedures for the Review of Federal Actions Impacting the Environment. February, 1987.

Alaska State Legislature

Juneau Delegation
Senator Dennis Egan
Representative Cathy Muñoz
Representative Sam Kito III

State Capitol
Juneau, Alaska
99801-1182

22 February 2016

M. Earl Stewart
Forest Supervisor, Tongass NF
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, AK 99901

Dear Mr. Stewart:

We are writing in response to the release of the Proposed Amended Land and Resource Management Plan (Proposed Forest Plan) and Draft Environmental Impact Statement (DEIS) for the Tongass National Forest. As you note in your release, the Proposed Forest Plan and associated DEIS are the first developed under the 2012 Planning Rule. We applaud your efforts and recognize the significance of charting a sound course for management activities in Southeast for the next 10 to 15 years.

As a delegation, we support a plan that manages for sustainability and encourages a viable and long-term timber industry that will provide jobs and opportunities for generations to come. In particular, we look forward to a plan that encourages renewable energy resource development and value-added timber processing so that, in keeping with Article VIII of the Alaska Constitution, these resources are used for the maximum benefit of Alaskans. We support local processing—turning timber into musical instruments, furniture, flooring, and other wood products—so that more Alaskans are employed for each acre harvested.

Providing clear and strategic guidance for the Tongass National Forest is an important priority for Southeast residents and businesses alike. We thank you for your attention to the public comments made on this issue and appreciate your diligence in incorporating this feedback into your final plan.

Sincerely,

Senator Dennis Egan	Rep. Cathy Muñoz	Rep. Sam Kito III
Senate District Q	House District 34	House District 33

CITY AND BOROUGH OF WRANGELL

INCORPORATED MAY 30, 2008

P.O. BOX 531 (907)-874-2381
Wrangell, AK 99929 FAX (907)-874-3952
www.wrangell.com

February 22, 2015

Forest Supervisor
Tongass national Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, AK 99901

Re: Comments on Proposed Tongass Nation Forest Land and Resource Management Plan
And the draft EIS

Thank you for allowing us this opportunity to comment on the Proposed Tongass National Forest Land and Resource Management Plan and the draft EIS.

Our understanding is that the primary changes in this plan is focusing on the transition from harvesting old growth to young growth. But as a community who has experienced the downside of the lack of a supply of old growth timber, we are concerned in the ability of the USFS to provide an economically viable supply of young growth timber, and to do it within the 15 year time frame as charged by the Secretary of Agriculture. We are concerned that the inventory data is generalized, and therefore we support and encourage development of an accurate inventory of young growth availability.

This inventory is critical for a complete and accurate economic analysis of the transition on communities and industry. Loss of harvesting volume is not a result in decline in demand, it is a result from the loss of economic sales available to industry and the slow process the USFS undertakes to develop sales due to an ongoing fear of lawsuits. No business can operate economically in such an environment and thus the loss in industry opportunity.

- The plan fails to consider social and economic metrics to measure outcomes of the transition from old growth to young growth. Metrics showing the impacts to industry and also to communities.

- Appendix C Watershed Analysis: There has been so much discussion of late regarding "watershed" analysis and impacts within the T77 watersheds. Based on our own personal experience with the Wrangell Island Sale, an actual stream "watershed" for a harvest unit or harvest area, may be smaller than the T77 defined watershed. Yet the USFS is trying to utilize the T77 watershed analysis. The Plan needs to clarify its definition and use of watershed analysis vs. the T77 watersheds.

- We support the relaxation of Standards and Guides for the harvest of Young Growth during the transition in land use designations that may normally minimize or prohibit some commercial harvesting if it will provide economic sales of young growth timber.

- Appendix F Visual Priority Routes and Scenic Integrity. According to our Wrangell District, for some reason it appears that all of Wrangell's Forest Roads are designated a Visual Priority Route. While we agree that the main roads do have a visual preference, not all of the roads need to be classified a visual priority route to limit timber or other use. (Originally, some of these designations were going to be dealt with in the upcoming Wrangell Island Sale, but now we understand that will not happen and we have to address it here. Only the road management plan – what stays open, what will be closed and level of use will now be addressed in the Wrangell Island Sale.) For example, the back side of the Nemo-Skip Loop Road (6267) (From Turn Island where the road turns northeast back to intersection of #6265 to Earl West) is heavily timbered and more out of site out of mind and a good area in which to continue to permit timber harvest. Yes it is on a loop so makes for a fun day trip, but there is nothing wrong with timber harvesting. Questions can be answered with educational materials about timber harvesting practices and economic values to communities.
  Every road on Wrangell Island will meet one of the primary criteria for a visual priority route – for example the water routes of small and midsize boats. We are on an island. Timber roads climb mountains that provide views, over looks are created for turn outs for logging trucks and once trees are harvested, you can see the water. It does not mean that each road should be a visual priority route. All roads should be analyzed as a whole, and key stretches of roads identified. Off shoots of some of the priority roads that receive minimal traffic could be reclassified as non visual priority.

- Tourism is the big growth industry since supply of timber to harvest and political affects have reduced the opportunity for the timber industry. The plan also fails in considering the social and economic metrics to measure outcomes of tourism growth for communities and businesses and the impacts to recreational sites

We understand that the USFS has selected as its preferred alternative, Alternative 5 that was proposed by the Tongass Advisory Committee. While the Borough is not agreeing or disagreeing with that alternative specifically, we do understand that their proposed amendment included additional recommendations that were not necessarily "plan" amendments. Yet their recommendation was to be presented as a package. If Alternative 5 is implemented, we believe the other components of their recommendation, including the monitoring, bringing stakeholder participation in earlier in planning processes, USFS internal culture change, inventory assessments and social economic impact analysis are critical components of any plan implementation strategy.

Sincerely,

Jeff Jabusch
Borough Manager

CC: Mayor David Jack
Borough Assembly
Carol Rushmore, Economic Director/Planner

ORGANIZED VILLAGE OF KASAAN

P. O. Box 26-Kasaan * Ketchikan, Alaska 99950-0340
(907) 542-2230 * (fax) 907-542-3006

Mr. Earl Stewart, Tongass Forest Supervisor
Tongass National Forest
648 Mission St.
Ketchikan, Alaska 99901

February 29, 2016

Dear Supervisor Stewart,

The Organized Village of Kasaan, a federally recognized Tribe, is utilizing our "Government-to-Government" relationship requesting the United States Forest Service end "Old Growth" logging as soon as possible. We feel that the current program of Old Growth logging for fifteen plus year is too long. We feel that the transition out of Old Growth Logging needs to be reduced to five years maximum.

We would like to work with the USFS to develop a Land and Resource Management Plan that protects the resources that sustain the people who live in Southeast Alaska.
Our Tribal Citizens survive off the land and sea, this is our Traditional and Cultural Way of Life. We need to protect our natural resources so they will continue to provide for our future citizens.

Our priorities are everything that contributes to our way of life and this includes; Fish habitat: Sockeye, Chum, Coho, steelhead and Trout, these fish need good streams so they can reproduce, they need good healthy Watersheds.
Even the USFS is saying that the most valuable product on the Tongass National Forest is now Salmon. According to Mr. Medel, who is the Fisheries Manager for the Tongass, has stated that the Tongass produces 25 per cent of all salmon harvested in the Northeastern Pacific Ocean.

The USFS must ensure that the Tongass' 77 watersheds, Audubon Society and the Nature Conservancy priority conservation areas, Phase 2 and 3 lands, and roadless areas are taken out of the old growth timber harvest areas. There should not be any logging in those areas, to protect our wildlife habitat.
The Organized Village of Kasaan Tribal Council would like to invite you to a "Government-to-Government" Consultation on this issue as well as Kendrick Bay Mining issues.

Please let us know what date and time would work for you to meet with us. We are going t o be requesting a "Government-to-Government" Consultation meeting also with Matt Anderson, and we'd like to have both of you at this meeting.

If you have any questions and/or need any further information, please feel free to contact me.

Thank You,

Ronald Leighton
President
Cc: Matt Anderson, POW District Ranger

KETCHIKAN GATEWAY BOROUGH

RESOLUTION NO. 2641

A Resolution of the Assembly of the Ketchikan Gateway Borough, Providing Comment on the Proposed Amendment to the 2008 Tongass Land and Resource Management Plan

RECITALS

A. **WHEREAS**, the U.S. Forest Service 2008 Tongass Land and Resource Management Plan (Forest Plan) was evaluated in 2013, five years after its issuance, to determine if the Forest Plan needs to be adjusted; and

B. **WHEREAS**, during the 2013 evaluation, the Assembly provided comments through Resolution 2471-Amended; and

C. **WHEREAS**, based on information from the 2013 review and a memorandum from the Secretary of Agriculture, the Forest Plan is proposed to be amended; and

D. **WHEREAS**, the Alaska Miners Association (AMA) and the Alaska Forest Association (AFA) have provided comments on the proposed amendment; and

E. **WHEREAS**, the Ketchikan Gateway Borough Assembly supports these associations and encourages careful consideration of their comments.

NOW, THEREFORE, IN CONSIDERATION OF THE ABOVE FACTS, IT IS RESOLVED BY THE ASSEMBLY OF THE KETCHIKAN GATEWAY BOROUGH as follows:

Section 1. The Ketchikan Gateway Borough Assembly requests that the Forest Service make changes to the proposed TLMP plan amendment as follows:

1) Modify the proposed amendment to include mining. Changes in federal policy have resulted in significant adverse impacts to mining activities. The 2008 Forest Plan should be amended to include enforceable mechanisms designed to promote mineral and strategic mineral exploration and development, and realistic access to mining claims and mining development.

2) Include mining in the Multiple Use Strategy for the Tongass. Mining is not adequately considered in the Transition Plan Draft. The Tongass Transition Plan Final Environmental Impact Statement, or a Supplemental Environmental Impact Statement, should include language that that makes mining part of the Multiple Use Strategy for the Tongass.

3) Modify the Roadless Rule. By precluding the construction of roads and harvesting of timber through the 2001 Roadless Rule, the ability to access existing mining claims, and explore for new mineral resources is severely compromised. The rule should be modified to allow for road construction and timber harvest necessary to accommodate the needs of the mining industry.

4) Include renewable energy as part of the Forest Transition Plan. The Forest Plan presents barriers to the development of hydropower and transmission facilities that could be used to provide clean, renewable energy to mining operations and local communities in lieu of non-renewable, greenhouse gas producing diesel generation.

5) Conduct a comprehensive biomass study. The principal purpose of the proposed amendment to the Forest Plan is to transition timber harvest away from old growth and toward younger growth stands. A study should be performed to accurately determine the amount of marketable young growth timber that could reasonably be expected to be made available to local mills and contribution to local economies; and

6) Conduct an economic analysis of the transition plan's impacts. Harvesting and processing smaller diameter young growth timber requires significantly different tooling and harvest techniques, as well as market structure development. The transition plan should be based on a comprehensive and detailed economic analysis of how the proposed change will impact the existing timber industry and its potential for growth. Such an analysis must include an accurate estimate of the amount of marketable timber that would be made available under the transition plan.

KB02-005

Section 2. Distribution. The Borough Clerk is requested to send copies of this resolution to the Secretary of Agriculture; the Tongass Forest Supervisor; Senator Murkowski; Senator Sullivan; Representative Don Young; the Alaska Miners Association and the Alaska Forest Association.

Section 3. Effective Date. This resolution shall be effective upon adoption.

ADOPTED this 16th day of February, 2016.

Alan Bailey, Vice Mayor,
for David Landis, Borough Mayor

ATTEST:

Kacie Paxton, Borough Clerk

APPROVED AS TO FORM:

Scott A. Brandt-Erichsen, Borough Attorney

Klawock Cooperative Association, Tribe
310 Bayview Blvd. - P.O. Box 430
Klawock, Alaska 99925
Phone: (907)-755-2265 - Fax: (907)-755-8800

February 25, 2016

Mr. Earl Stewart, Tongass Forest Supervisor
Tongass National Forest
648 Mission Street
Ketchikan, Alaska 99901

Dear Supervisor Earl Stewart:

Many Americans do not realize that Indians, the first inhabitants of the land, were not granted full citizenship until 1924. By that time, the lands and waterways of Southeastern Alaska had been claimed by prospectors, canneries, cities and towns, and, finally, by the creation of the Tongass National Forest. Since they were not considered citizens, the Indians had little or no voice in what was happening to them. Even after citizenship, court decisions such as that in the Tee-Hit-Ton case, ruled that their fishing rights were noncompensable under the Fifth Amendment because Congress had never recognized those rights. [1]

I am submitting this letter to you on behalf of the Klawock Cooperative Association, utilizing our government-to-government relationship to urge the Forest Service to end old growth logging sooner, rather than later. Going forward, we need a land and resource management plan that protects the resources that sustain the people who live in Southeast Alaska. Continuing the current program of old growth logging at current levels for fifteen-plus years is far too long. The transition out of old growth logging needs to be reduced to five years maximum.

The Tribe's highest priority is salmon habitat. This habitat is in rapid decline. The degradation of environmental quality caused by population growth, climate change, economic development, and the politics of public policy are to blame.

The largest natural resource available to Klawock Tribal members is the Klawock River watershed, once the largest producer of salmon in the commercial fisheries and major subsistence fisheries resources for Prince of Wales Island. Subsistence fish species important to our citizens, which have been traditionally, and are currently harvested from the Klawock River watershed, include sockeye salmon, coho salmon and steelhead trout. Sockeye salmon, the most important fish resource for numerous communities on Prince of Wales Island, show historical Klawock watershed escapement estimates as high as 80,000 fish. In 2014 and 2015 the escapement was 6,196 and 8,800 sockeye salmon respectively.

The US Forest Service says the most valuable product on the Tongass National Forest is now salmon. Ron Medel is the Fisheries Manager for the Tongass. According to Medel, the Tongass produces 25 percent of all salmon harvested in the Northeastern Pacific Ocean. He's been studying this question since 2010. [2]

We must begin treating the salmon like the economic powerhouse and lifeblood of the indigenous people that is. The Forest Service must ensure that Tongass 77 watersheds, Audubon and The Nature Conservancy priority conservation areas, phase 2 and 3 lands, and roadless areas are taken out of the old growth timber pool. There should be absolutely no logging in those areas if we are to protect wildlife habitat. The logging of original

The Klawock Cooperative Association, ("the Tribe"), is a duly constituted Indian Tribe organized pursuant to the authority of Section 16 of the Act of Congress of June 18, 1934 (48 Stat. 984), amended May, 1 1936 (49 Stat. 1250). The Klawock Cooperative Association Tribal Council is a duly elected governing body of the Tribe, authorized to act by and on the behalf of its members.

productive old growth, according to the Forest Service, is listed at only eight percent; however, perhaps half of the rare big-tree old growth has been targeted and cut. These are the most important stands for fish, wildlife and ecosystem integrity.

We are at a critical juncture, the plans and policies we are discussing right now will reshape our land. While the intentions here are not to destroy the salmon, this crisis is centuries in the making.

Humans have conducted at least three full-scale experiments on how well salmon adapt to a changing landscape. Salmon failed each time, first in Great Britain, then New England, and now the Pacific Northwest. The strikingly similar history of salmon in these three regions carries clear implications for modern salmon recovery efforts. [3]

It is no secret that hatcheries are no substitute for lost habitat. These warnings continue to fall on deaf ears as small Tribal Governments and countless non-profits spin their wheels funding study after study, trying to stand between a threatened cultural icon and the failing policies that will inevitably lead to its extinction, all the while being thwarted by political agendas and bureaucratic inertia.

This juncture provides us with the burden of perhaps the greatest opportunity in the nation, if not the world, for protecting the largest intact temperate rainforest on earth. How we handle this crisis may foretell the fate of many other regions and ecosystems.

What does it say for the long-term prospects of endangered species around the world if one of the most prosperous regions of the richest country on Earth cannot accommodate its own icon species? [3]

Very Respectfully,

Lawrence Armour
Tribal Administrator
Klawock Cooperative Association

1. **Robert E. Price. "The Great Father in Alaska"** ***The Case of the Tlingit and Haida Salmon Fishery.*** **1990. PG xiii – ix. (Foreword by Wallace M. Olsen, UAS). First Street Press, Douglas, Alaska.**

2. **Robert Woolsey. (2015, May 7). USFS Fisheries: Salmon top Tongass product. Retrieved from http://www.kcaw.org/2015/05/07/usfs-fisheries-tongass-lands-produce-ocean-wealth/**

3. **David R. Montgomery. "King of Fish"** ***The Thousand-Year Run of Salmon.*** **2003. PG 3, 5. Westview Press, a member of the Perseus Books Group.**

The Klawock Cooperative Association, ("the Tribe"), is a duly constituted Indian Tribe organized pursuant to the authority of Section 16 of the Act of Congress of June 18, 1934 (48 Stat. 984), amended May, 1, 1936 (49 Stat. 1250). The Klawock Cooperative Association Tribal Council is a duly elected governing body of the Tribe, authorized to act by and on the behalf of its members.

LAWRENCE ARMOUR
KLAWOCK COOPERATIVE ASSOCIATION, TRIBE
310 BAYVIEW BOULEVARD
KLAWOCK, AK 99925

ATTN: EARL STEWART
FOREST SUPERVISOR'S OFFICE
TONGASS NATIONAL FOREST
648 MISSION STREET
FEDERAL BUILDING
KETCHIKAN, AK 99901-6591

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Ketchikan Indian Community
Cultural Resources Department
429 Deermount Street.
Ketchikan, AK 99901
(907) 228-9445

February 22, 2016

Forest Supervisor, Tongass National Forest
Attn: Forest Plan Amendment
648 Mission Street, Ketchikan, AK 99901

Re: Tongass Land and Resources Management Plan (Forest Plan) Amendment

Ketchikan Indian Community (KIC) has benefited by having USFS staff attend Tribal Council meetings reporting on activities and projects of concern to the tribe. Continuing to support this level of communication will inevitably lead to increased cooperation and collaboration between USFS and KIC in the coming months and years.

KIC is appreciative in general of the USFS's attempt on behalf of the general public to protect and preserve our National Forests for suitable and sustainable multiple use goals and objectives. Some of those Uses found listed in Chapter 2 for the Forest Plan (i.e. Biodiversity, Fish, Wildlife, Plants, Soil and Water, Wetlands Heritage Resources, Sacred Sites and Subsistence) to name a few of the twenty (20) Uses specified are very key to tribal members. It is important for USFS to remember that though "Timber" Use predominates the planning effort and staff resources "Timber" still only 1 out of 20 Multiple Uses specified to be managed for in the Tongass Forest Plan.

Timber harvest should not negatively impact the other identified goals and objectives of the Forest Plan disproportionate to its value, especially when it is not supporting a significant number of private sector jobs. It is my understanding that approximately half the trees logged on the Tongass are exported as unprocessed logs. On the surface this business model requires little long-term investment in Alaska and employs comparatively few Alaskans and potentially squanders a valuable resource.

Southeast Alaska's culture and economy is based on a well-functioning ecosystem. Ecosystem Services and the secondary benefits provided by a healthy forest include both the subsistence resources: fish, deer and berries, that fill freezers of many KIC members; and to employment opportunities and dollars brought in by tourism and fishing. To this end it would be desirable to focus forest management resources at restoring watersheds impacted by logging and support job creation in fishing, hunting, general outdoor recreation, renewable energy, mariculture and tourism.

In regards to the Forest Plan Preferred Alternative 5: There is concern over impacts to Riparian Management Areas (RMAs), especially Beach and Estuary fringe areas where the likelihood of damaging subsistence and cultural heritage resources is greater than upland areas. Nevertheless, Beach and Estuary fringe areas become less protected with this new Forest Plan. Additional

oversight by USFS staff would be essential to minimize impacts and mitigate damages of any land disturbing activity in Beach and Estuary fringe areas permitted under this new Forest Plan.

Another concern is what will be required to be monitored before during and after timber harvest, in other words the quality and quantity of monitoring. It is our understanding that a separate Monitoring Plan tied to this Forest Plan will be developed in the near future. In a recent meeting of TAC it was stated and not disputed that due to limited USFS staff some logging sites have in the past received only a windshield surveys, rather than boots on the ground for through and frequent inspections. We strongly encourage a robust monitoring plan and enough staff to be present at logging sites before during and after harvest. Supported by a budget that is adequate to accomplish this task, funded if necessary by increased fees paid by companies harvesting timber to allow for this monitoring and subsequent restoration. And that this Monitoring Plan be developed sooner rather than later and applied retroactively to timber sales approved and ongoing before such a Monitoring Plan is complete and approved.

Tribal Members especially those actively engaged in carving and weaving are extremely concerned over status of Yellow Cedar. Tlingit, Haida and Tsimshian people use the rot-resistant wood for canoe paddles and totem poles. They can take a lengthwise strip of bark from a living tree for weaving baskets and hats, and as backing in blankets. The tree can compartmentalize the injury and continue growing. However, the yellow cedar's shallow roots make the tree vulnerable to changes brought on by climate warming. It is our understanding that the USFS has been studying yellow cedar decline in Southeast Alaska for many years. A 2014 USFS finding document states "substantial information indicating that listing this species may be warranted". If this is the case, and tribal members feel that it is, the Forest Plan should limit timber harvest of healthy Yellow Cedar until this issue of decline can be addressed. With the goal of maintaining healthy stands of Yellow Cedar wherever possible for as long as possible.

KIC does not outright oppose the Timber Industry but desires harvesting to be done in a sustainable way rather than driven by short-term economic gain for a relative few companies and individuals. We strongly encourage USFS to only implement forest management actions that protect and maintain, subsistence and cultural values. Southeast Native Alaskans, and other people groups derive significant value from a healthy Tongass National Forest and surrounding ecosystem. Keeping it that way is essential for what KIC Leadership considers "Our Way of Life".

I am appreciative of the opportunity for review documentation and to provide input.

Sincerely,

Tony R Gallegos, Cultural Resources Director
Work: (907) 228-9445
Email: tgallegos@kictribe.org

CITY OF KETCHIKAN, ALASKA

RESOLUTION NO. 16-2618

A RESOLUTION OF THE CITY OF KETCHIKAN, ALASKA PROVIDING COMMENT ON THE PROPOSED AMENDMENT TO THE 2008 TONGASS LAND AND RESOURCE MANAGEMENT PLAN; AND ESTABLISHING AN EFFECTIVE DATE

WHEREAS, the U.S. Forest Service 2008 Tongass Land and Resource Management Plan (Forest Plan) was evaluated in 2013, five years after its issuance, to determine if the Forest Plan needs to be adjusted;; and

WHEREAS, based on information from the 2013 review and a memorandum from the Secretary of Agriculture directing the transition to young growth, the Forest Plan is proposed to be amended; and

WHEREAS, the Alaska Miners Association and the Alaska Forest Association have provided comments on the proposed amendment; and

WHEREAS, the Council of the City of Ketchikan supports these associations and encourages careful consideration of their comments.

NOW, THEREFORE, BE IT RESOLVED by the Council of the City of Ketchikan, Alaska as follows:

Section 1: The Council of the City of Ketchikan, Alaska, requests that the Forest Service make changes to the proposed TLMP plan amendment as follows:

1. Modify the proposed amendment to include mining. Changes in federal policy have resulted in significant adverse impacts to mining activities. The 2008 Forest Plan should be amended to include enforceable mechanisms designed to promote mineral and strategic mineral exploration and development, and realistic access to mining claims and mining development.

2. Include mining in the Multiple Use Strategy for the Tongass. Mining is not adequately considered in the Transition Plan Draft. The Tongass Transition Plan Final Environmental Impact Statement, or a Supplemental Environmental Impact Statement, should include language that makes mining part of the Multiple Use Strategy for the Tongass.

3. Modify the Roadless Rule. By precluding the construction of roads and harvesting of timber through the 2001 Roadless Rule, the ability to access existing mining claims and explore for new mineral resources is severely compromised. The rule should be modified to allow for road construction and timber harvest necessary to accommodate the needs of the mining industry.

4. Include renewable energy as part of the Forest Transition Plan. The Forest Plan presents barriers to the development of hydropower and transmission facilities that could be used to provide clean, renewable energy to mining operations and local communities in lieu of non-renewable, greenhouse gas producing diesel generation.

5. Complete a comprehensive biomass inventory. The principal purpose of the proposed amendment to the Forest Plan is to transition timber harvest away from old growth and toward younger growth stands. An inventory should be performed to accurately determine the

amount of marketable young growth timber that could reasonably be expected to be made available to local mills and contribute to local economies; and complete an accurate inventory of all merchantable and economically marketable old growth timber that can contribute to sustaining local communities.

6. Complete an economic analysis of the transition plan's impacts. Harvesting and processing smaller diameter young growth timber requires significantly different tooling and harvest techniques, as well as market structure development. The transition plan should be based on a comprehensive and detailed economic analysis of how the proposed change will impact the existing timber industry and its potential for growth. Such an analysis must include an accurate estimate of the amount of marketable timber that would be made available under the transition plan. Such analysis must include determination of the amount of federal funding required to meet the plan's goals and outputs annually over the planned period.

Section 2: The city clerk is requested to send copies of this resolution to the Secretary of Agriculture; the Tongass Forest Supervisor; Senator Murkowski; Senator Sullivan; Representative Don Young; the Alaska Miners Association and the Alaska Forest Association.

Section 3: This resolution shall become effective immediately upon passage.

PASSED AND APPROVED by a duly constituted quorum of the City Council for the City of Ketchikan on this 18th day of February, 2016.

Lew Williams III, Mayor

ATTEST:

Katherine M. Suiter, City Clerk

CITY of KUPREANOF
PO BOX 50
PETERSBURG, ALASKA 99833
PHONE : 907-340-2400

Earl Stewart, Forest Supervisor
Tongass National Forest
648 Mission St.
Ketchikan, AK 99901
Re: Tongass Land and Resource Management Plan

comments-alaska-tongass@fs.fed.us

February 22, 2016

Dear Mr. Stewart,

The City of Kupreanof respectfully submits the following comments in response to the Draft Environmental Impact Statement (DEIS) of the Proposed Tongass Land and Resource Management Plan (LRMP). Due to the past half century of politically-driven decisions of your predecessors to sign-off on unsustainable, large-scale industrial clearcutting of the Tongass National Forest, our island ecosystems have been tragically compromised on an island-wide, landscape level of impairment. Elsewhere whole watersheds have been rendered incapable of maintaining stable and productive populations of Sitka blacktail deer and are no longer capable of meeting basic local subsistence needs.

The entirety of nearby Mitkof Island has suffered the most restrictive season and bag limits in all of Southeast for the last 45 years. These restrictions to local hunters remain in place to this day even after a total hunting closure which lasted over 17 years. Previous to large-scale clearcutting which targeted low elevation, high volume old growth on Mitkof island, the area provided among the most abundant deer populations in all of Southeast Alaska.

In 1961, the Alaska Department of Fish and Game (ADFG) published a statistical summary of the season's deer hunter harvest in all Southeast communities. In terms of hunter success, Petersburg ranked the highest of all communities of Southeast with a hunter success rate of 97%.

In 1961 Petersburg ranked the highest of all communities of Southeast in terms of highest average number of deer per hunter, (3.5 deer per hunter), with a season total of over 1922 deer by 549 hunters.) However, in 2012, 147 hunters on Mitkof Island required 565 deer hunter days to harvest just 22 deer.[1]

To make matters worse, in 2013, even as the remaining high value old growth timber was being clearcut (Tonka Timber Sale) on nearby Lindenberg Peninsula, the same hunting restrictions were imposed by emergency order and remain in place for the foreseeable future.

Other old growth dependent species such as the Alexander Archipelago wolf (*Canis lupus ligoni*) of Prince of Wales Island (Unit 2), face such precipitous declines in the face of large scale timber extraction in the on-going Big Thorne Timber Sale, that according to ADFG wolf researcher, Dr. David Person,

> *"the Big Thorne timber sale, if implemented, represents the final straw that will break the back of a sustainable wolf-deer predator-prey ecological community on Prince of Wales Island…"*

Still other old growth dependent species such as marten, Queen Charlotte goshawk, and several other species demonstrate population declines consistent with biological research demonstrating the debilitating effects of habitat fragmentation resulting from even age (clearcutting) management and the associated logging road system.

Despite these documented failures of an agency whose byline is, "Caring for the Land, and Serving People", the United States Forest Service (USFS) remains committed to singling out the Tongass as the only public forest in the entire National Forest System in which large scale industrial old growth timber extraction continues apace, while being fully aware of long-standing negative, economic, environmental, and social consequences.

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[1] ADF&G, 2014. Deer hunter survey summary statistics. Alaska Dept. of Fish and Game. Division of Wildlife Conservation. Juneau. WINFONET database.

The problem of even age management was identified in the early 1960's and summarized in a technical report produced by ADFG back in 1985, titled, *"The impacts of Clearcut Logging on the Wildlife Resources of Southeast Alaska."*

The very first paragraph to the introduction of this report states,

> *"Logging, as currently practiced and planned in southeast Alaska, has the potential to significantly and permanently alter large amounts of wildlife habitat.Wildlife species which are adapted to use existing habitat may decline and associated recreational and subsistence uses may be substantially reduced."*

So it cannot be said, the large scale mismanagement which has occurred on the Tongass was not well known, nor its actions constituted unintended consequences. Rather, the agency has consistently operated and remains, in a state of regulatory capture[2].

"Addressing sustainable forestry in Southeast Alaska"

An industry-wide shift out of old growth logging to second growth was first pitched by the agency in 2010 at the Tongass Futures Roundtable (TFR.) Within 3 years, the TFR was disbanded, but barely two months later, Secretary Vilsack's Memorandum of 2013[3] was issued. In that memorandum, radical revisions of the timber industry were outlined, with the execution of the Big Thorne Timber Sale (the largest timber sale in well over a decade) pitched as the first step in "addressing sustainable forestry."

The Memorandum included an entreaty to Congress to legislatively eliminate the silvicultural standard known as CMAI, or Cumulative Mean Annual Increment, which represented the methodology for maximizing timber yield by ensuring that timber would not be cut prior to achieving its greatest rate of regrowth. The consequences of this revision means that all second growth (rebranded as "young growth") would no longer be managed to achieve the crucial structure, function, or compositional characteristics which old growth dependent wildlife of our coastal temperate rainforest have adapted to and require in order maintain, "viable, well distributed populations" as promulgated in the National Forest Management Act of 1976 (NFMA.)

The consequence of this Secretarial edict constitutes nothing less than a permanent conversion of the (formerly) highest value, most biological productive old growth habitat

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[2] https://en.wikipedia.org/wiki/Regulatory_capture

[3] Secretary's Memorandum 1044-009 "Addressing Sustainable Forestry in Southeast Alaska"

of the Tongass National Forest into corporate tree plantations which are incapable of functioning under the mandate of Multiple Use, and incapable of maintaining the sustainable yield of old growth dependent plants and animals central to subsistence needs of rural residents.

Ultimately, the "Transition" was re-pitched at the Tongass Advisory Committee (TAC), a full 6 years after its announcement at the TFR and is now found in the DEIS Proposed Amendment to the LRMP. The public has been reassured in this document with terms such as "Transition," "Stewardship," and "Restoration."

The terms seem to indicate an (albeit after-the-fact) agency acknowledgement that the decades of overwhelming public outcry over unsustainable old growth timber extraction has been heard, and an agency paradigm shift is afoot. Those familiar with corporate marketing tactics such as 'bait and switch,' 'rebranding,' and 'spin,' however, understand instead, that something else is *under*foot.

The TAC implementation, process, representation, and premises used to lend the patina of legitimacy and unbiased deliberation to the LRMP is a transparent demonstration of manufactured consensus for rubber stamping the predetermined outcome defined in Secretary Vilsack Memorandum.

These abuses of the Federal Advisory Committee Act (FACA) abetted by the agency's handpicked membership of the TAC demonstrate the agency intended from the outset to run roughshod over the intent of FACA. The LRMP DEIS itself, is fatally flawed in its Purpose and Need statement in that it excludes a full range of alternatives and with that, major disclosures of environmental impacts and the requisite "hard look" delineated in the National Environmental Policy Act. The National Forest Management Act, and other benchmark environmental and procedural laws in the pursuit of business as usual and it does not reflect well on the agency, nor the continued imposition of its failed business model on the regional economy, the environment, and the social wellbeing of Southeast Alaskans.

Economic Overview

A cursory overview of the LRMP, coupled with the documented historical record, demonstrates the Proposed Alternative reveals the actual shift away from industrial clearcutting of old growth will not occur for 15 years or more. This period of time will render moot what little remains of the existing old growth habitat, as it will be liquidated.

The agency allowance of up to 50% or more of raw log exports to China, Japan, South Korea and elsewhere continues. The net effect of these policies preclude the most viable options and opportunities for providing local small mill owners access to local old growth timber. The small mills cannot add sufficient value to young growth nor can they compete on the scales of volume necessary to remain competitive. The DEIS fails to provide the analysis necessary to examine these inevitable outcomes.

While the lion's share of the agency budget continues to increase the size of a burgeoning corporate tree plantation occurring within the most biologically critical, highest volume, easiest to access, low elevation watersheds, the industrial scale, even age management regime condemns present and future opportunities of local small mill owners from access to viable livelihoods.

Further, the DEIS fails to examine alternative economic scenarios in which forest dependent industries such as ecotourism, commercial fishing, recreation, sport hunting and fishing sectors are allowed to operate in an economic scenario free from the deleterious impacts of corporate tree plantations within the same landscapes.

Any objective analysis of the last fifty years of the timber industry in Southeast Alaska must conclude the wholesale felling and foreign export of the region's old growth rainforests allowed temporary profit taking for a few — while exerting a profoundly negative constellation of cultural, ecological, social, and economic consequences — for the many. On federal lands alone, a limited calculation of explicit economic consequences to U.S. taxpayers totaled over a billion dollars within a 30 year period [4] of federal timber sales. The implicit ecological and social subsidies remain unaccounted and largely ignored. The explicit economic subsidies to the timber industry are more aptly described as a corporate welfare system than an "industry" competing in the "free market."

For these reasons, the City of Kupreanof respectfully requests the USFS revisit its obligation to fulfilling the full intent of NEPA, NFMA, FACA, and the Administrative Procedures Act by abandoning the current DEIS and conducting a revised DEIS.

Sincerely,
David Beebe
Vice Mayor
City of Kupreanof

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[4] 1980-2010 Alaska Wilderness League akbriefing.wikispaces.com

Sitka Tribe of Alaska

Tribal Government for Sitka, Alaska

February 4, 2016

Earl Stewart, Forest Supervisor
Tongass National Forest
Attn: Forest Plan Amendment
648 Mission St.
Ketchikan AK, 99901

RE: Sitka Tribe's Comments on the DEIS for the Proposed Amendments to the TLMP

Dear Mr. Stewart,

I write on behalf of Sitka Tribe of Alaska (STA), tribal government for over 5,000 tribal citizens located in Sitka, Alaska. As a tribal government, STA is responsible for the health, welfare, safety and culture of its citizens. STA respectfully submits the following comments on the Draft Environmental Impact Statement (DEIS) for the proposed amendment to the Tongass Land Management Plan (TLMP).

The STA Tribal Council reviewed the DEIS for the proposed amendment to the TLMP with Sitka Ranger District staff at a February 2, 2016 government to government consultation. During the consultation the Council stated that they would be comfortable with alternative plan 4 or 5 as presented in the DIES. The Council also emphasized their support of any action that has the least impact on Sitka Blacktail Deer habitat.

If you have any questions regarding these comments contact STA's resource Protection Department Director Jeff Feldpausch at (907)747-7469 or email jeff.feldpausch@sitkatribe-nsn.gov.

Sincerely,

Michael A. Baines

Michael Baines
Council Chairman
Sitka Tribe of Alaska

Cc: Perry Edwards, Sitka District Ranger, Tongass National Forest

456 Katlian Street • Sitka, Alaska 99835 • (907) 747-3207 • Fax (907) 747-4915

Trust
Land Office

2600 Cordova Street, Suite 100
Anchorage, AK 99503
Tel 907.269.8658
www.mhtrustland.org

February 22, 2016

Re: Comments on Tongass Land and Management Plan, DEIS, November, 2015

Ladies and Gentlemen:

The Alaska Mental Health Trust Land Office (TLO) is submitting the following comments regarding the Tongass Land and Management Plan, Draft Environmental Impact Statement (DEIS), released November, 2015.

Significant Issues: **Timber Supply**

The proposed plan amendment is the implementation of a July, 2013 memo from the Secretary of Agriculture, Tom Vilsack (Secretary's Memorandum 1044-009) which directs the U. S. Forest Service (USFS) to transition its forest management program on the Tongass National Forest (Tongass) to a primarily young growth forest management program. The USFS has determined that this transition requires a forest plan amendment. The TLO manages lands for the Alaska Mental Health Trust and has been engaged in a proposed land exchange with the USFS for several years. This is referred to as the Alaska Mental Health Trust Land Exchange (Trust Land Exchange) within the DEIS. The USFS signed an Agreement to initiate a land exchange in June, 2015. The Trust Land Exchange is referenced throughout the DEIS and is considered a reasonably foreseeable action. Attached please find a letter dated November 19, 2013 from Secretary Vilsack to Senator Lisa Murkowski. In this letter Secretary Vilsack states:

> *"I appreciate your suggestions. As stated in my July 2, 2013 Memorandum 1044-099, Addressing Sustainable Forestry in Southeast Alaska, the transition of the Tongass timber program will be done in a way that preserves a viable timber industry so businesses can re-tool to process young growth timber efficiently.*
>
> *The proposed Trust Land Exchange, which was developed in collaboration with a variety of stakeholders and supported by the Tongass Futures Roundtable, would convey to the Department of Agriculture's Forest Service approximately 18,000 acres of Trust land adjacent to the communities of Juneau, Petersburg, Wrangell, Sitka, and Ketchikan, Alaska. Due to their proximity to communities, it would be difficult for most of these lands to be developed by the Trust in keeping with the Trust's mission. The 21,000 acres of national Forest Systems lands that*

would be conveyed to the Trust under the proposed exchange include approximately two-thirds old growth and one-third young growth timber, and are in areas more suitable for development.

I agree that the proposed land exchange could well serve the objectives outlined in my Memorandum:

1. *To seek opportunities to supply sufficient old growth "bridge timber" while the industry re-tools for processing young growth. The opportunity to use the exchange lands could help in providing part of the bridge to second growth.*
2. *Scenarios that effectuate a more rapid transition by prioritizing and developing additional young growth and restoration projects that could be completed over the next 5 years.*
3. *To intensify work with rural development to pursue opportunities to facilitate investments in re-tooling, and to develop by December 31, 2013, in collaboration with Rural Development and other stakeholders, a plan for providing financial assistance to re-tool timber processing equipment in Southeast Alaska to assist the industry to efficiently handle young growth timber.*
4. *To pursue partnerships with foundations, non-profits, corporations, and others to advance a second growth industry, undertake restoration projects, and otherwise speed the transition. This will include developing new markets for products developed by industry.*

Again, thank you for writing. An equal value land exchange between the Trust and the Forest Service will be properly and promptly considered. It will also help strengthen and diversify local economies throughout Southeast Alaska."

Thomas Vilsack
Secretary

The Secretary's letter states, "*I agree that the proposed land exchange could well serve the objectives outlined in my Memorandum.*" For this reason, the USFS needs to facilitate the Trust Land Exchange in the most expedient manner possible. The timber resources that will be made available through this exchange are critical to the preservation of the current Southeast Alaska forest products industry. Although the Sealaska Land legislation was passed by Congress, it only provides for the needs of one segment of the current industry. The current forest industry that is reliant upon public lands (including State and TLO) will have no timber that is NEPA cleared once the current contracts expire. Industry has stated that it will be out of wood in 2017.

"In choosing the timber sale offer level, it is important to anticipate the consequences of decisions. In terms of short-term economic consequences, over-supplying the market is less damaging than under-supplying it. If more timber is offered than purchased in a given year, the unsold volume is still available for purchasing off-the-shelf or re-offered at a minimal investment. However, a significant shortfall in timber supply available for harvest can be financially devastating to the industry." (Pg. G-8, DEIS Vol. II)

As stated in the DEIS above, *"a significant shortfall in timber supply available for harvest can be financially devastating to the industry."* Sufficient supply to industry is critical to achieving the objectives outlined in Secretary Vilsacks' memo. The DEIS, Table 3.12-12, uses a total estimated available volume of 136 MMBF from all landowners; it states 46 MMBF from the National Forest. Footnote 2 of the table says that 70 MMBF will be harvested on native corporation lands and 20 MMBF from State lands. Sealaska has announced on numerous occasions that it will harvest 45 MMBF annually from its lands to provide sustainable harvest levels. This leaves a shortfall of 25 MMBF per year. Village Corporation lands were harvested beginning in 1980; the earliest substantive volumes from that source will not be available until 2030 to 2040. The allowable harvest from all State lands controlled by the Division of Forestry in Southeast Alaska is about 20 MMBF, from all sources including the University of Alaska and the Alaska Mental Health Trust Lands (TLO). The University of Alaska has very limited resources to contribute to the annual harvest (traditionally less than 1 MMBF/year average), and the current AMHT timber is unavailable because of the on-going land exchange. For these reasons it appears a significant shortfall of timber supply will exist.

The Forest service has worked in good faith to comply with the Secretary's directive to preserve a viable timber industry. It is apparent, however, that the required timeline needed to complete NEPA projects and have second growth timber of sufficient size and age to supply timber to maintain the industry over time is rapidly dwindling. The USFS has historically been the sole supplier of timber to industry in SE Alaska. Although other landowners are diligently attempting to assist in this, the requirements of the Tongass Timber Reform Act (TTRA) Sec. 101 (Appendix E) and ANICA Section 705(a) (Appendix F) states that *"the secretary shall"* provide a supply of timber from the Tongass National Forest which meets annual demand and the market demand for each planning cycle. The USFS sharing this responsibility appears to be in conflict with this directive.

Significant Issue: **Young-Growth Transition**

The USFS is working collaboratively with the State of Alaska to do a comprehensive inventory of young-growth volumes available under the proposed plan amendment. There are currently no reliable growth models which accurately estimate the volume of timber per acre at a given age on the Tongass. The young growth timber volumes utilized in the DEIS use speculative estimates to determine the volume of wood which will be available at a given time.

The Secretary of Agriculture has directed the USFS to transition to young growth only timber harvest within 15 years. To aid in identifying a feasible transition strategy, the USFS formed the Tongass Advisory Committee (TAC). The TAC met in 2014 and 2015 and developed recommendations to facilitate the proposed transition. There was division within the diverse 15-member committee as to whether the proposed transition was possible within the specified timeline.

Several key issues were identified during the TAC meetings. The primary concern of the industry representatives on the TAC was the availability of young-growth timber of sufficient age to meet the required volumes to maintain the existing industry. Traditionally, silvicultural specialists on the Tongass recognized a rotation age (period of time between harvests) of 100 to 120 years. The vast majority of timber harvests on the Tongass occurred between 1955 and 1996. Simple math recognizes that the next rotation would then begin in 2055. This means that the large areas harvested starting in 1955 are only 61 years old. For this reason, the USFS worked with Congress to exempt limited areas of the Tongass from the Culmination of Mean Annual (CMAI) requirement. The relaxation of the CMAI requirements allows harvest of select areas at a younger age than federal requirements would normally allow. The TAC was concerned that early harvest of these stands would jeopardize later harvest volumes.

A review of the USFS supplied literature in the DEIS regarding young-growth volumes and availability is speculative. The TAC recognized that of the total 435,000 acres of potential young growth (YG) on the Tongass, only 273,000 acres are considered "suitable and available" (S&A) for timber harvest. Furthermore, out of the total 273,000 acres of S&A, only 186,000 are considered "Timber Management" Land Use Designation (LUD). This is only 43% of the lands previously harvested on the Tongass and does not account for the typical loss of acreage for various conservation issues that typically occur during timber sale preparation. To successfully implement the Plan Amendment, the recommendations of the TAC regarding "Old Growth Bridge Strategy" page 12, TAC Recommendations-May 2015 must be implemented. To maintain the required timber volumes, the TAC suggested that old growth volume be added during this transition period to supplement the available young growth volume.

Significant Issue: **Renewable Energy**

The development of renewable energy projects should continue on the Tongass. The development of bio-fuel/municipal waste power plants may provide a solution to the municipal waste being generated while utilizing wood which is not of sufficient size to meet saw log specifications. A facility such as this could be co-located with a forest product value-added facility. A proposed project of this nature is being considered in the Ketchikan Area. Facilities which can maximize utilization of all harvested fiber will be key in a successful transition (see economic discussion).

Significant Issue: **Economics**

The Economic and Social Environment section of the DEIS lacks substantive discussion of the cost to harvest, transport, and produce a manufactured product. The DEIS (Figure 3.22-5, page 3-451) shows significant reduction of timber harvest by all owners other than the State of Alaska. The discussion below this graph states that of the 22 active sawmills in 2007 only 10 remained active mills in 2014. Although the "Potential Lumber Markets" pg. 3-461 discussed potential markets for dimensional lumber, it did not include operational costs, cost of logs delivered to sawmills, or the cost of transporting product to markets. The difference in operational costs to an Alaskan facility conducting harvest operations and converting logs to lumber is considerably higher than its lower 48 counterpart. According to *Random Lengths*, a well-recognized sawmill trade journal, the average price for Composite Framing Lumber is $280 per thousand board feet (MBF). This average is over several decades. The USFS has failed to illustrate how an Alaskan sawmill with logging costs of $350 per MBF and $100 per MBF cost to convert logs to lumber and additional transportation costs can be economically viable producing composite lumber. If composite lumber is not the projected product, the DEIS fails to show an alternative product.

Note graphs on pages 3-482 and 3-483 (Net Revenue). Figure 3.22-17 is net revenue for Old Growth and Figure 3.2-18 is net revenue for Young Growth (YG). When you add the values together for a 5-year period, in most cases the total net revenue is negative in value. As an example, alternative 5 (preferred alternative) in years 16-20 (a period when the transition has been completed and YG makes up the majority of the volume being offered), the total net revenue sum is a negative $10 million. How can the USFS have a timber sale program that is negative value when Public Law 112-74, House Report 2055-257, Section 414 allows the USFS to offer only positive value timber sales?

Conclusion:

An analysis of the DEIS timber supply plan leaves serious concern of Forest Service's ability to obtain Secretary Vilsack's directive to transition its forest management program on the Tongass National Forest (Tongass) to a primarily young growth forest management program. The Tongass has arbitrarily chosen 10 to 15 years to achieve this objective. The DEIS has not demonstrated that it can achieve this objective and maintain the current SE Timber Industry.

To successfully implement the Plan Amendment the Forest Service should:

- Implement all recommendations of the TAC; especially regarding "OGR's, RMAs, Outside of TTRA, and Beach Buffers"; page 11 and "Old Growth Bridge Strategy" page 12; TAC Recommendations-May 2015.

- Finalize partnerships which collaboratively work with the other Landowners, State of Alaska, Sealaska Corporation, Alaska Mental Health Trust, and University of Alaska.
- Expedite the finalization of the Alaska Mental Health Trust Land Exchange, AMHT Land Exchange (5X-18).

Sincerely,

John Morrison
Executive Director
Trust Land Office

Attachments:
Alaska Board of Forestry Letter - 1/25/2016
USDA, Vilsack, Letter to Senator Murkowski - 11/19/2013

Date submitted (UTC): 1/31/2016 6:13:23 PM
First name: Rep.
Last name: Josephson
Organization:
Title:
Official Representative/Member Indicator:
Address1:
Address2:
City:
State:
Province/Region:
Zip/Postal Code:
Country:
Email: Rep.Andy.Josephson@akleg.gov
Phone:
Comments:
Tongass National Forest Management Plan (due Feb 22, 2016)

Dear Ms. Howle:

I am not a scientist, a fisheries biologist, a timber man or an expert on forest ecology. I am an armchair observer of Tongass politics and the forest itself. I am a student of public policy and a citizen concerned with our future.

To the extent the following comments can be woven into others and into the USFS?s management plan update, I would appreciate it.

My own beliefs are that:

1) What we are doing as a people is not sustainable. The Earth wasn?t designed to hold $7 billion all vying for scarce resources. Pressures on those resources are being felt every day. Sometimes the wiser mover is the conservative one?conserving a resource. And more than Gifford Pinchot may have foreseen. To the extent possible, leave the Tongass Forest in tact, and alone.

2) Do not sell uncut timber, without value added, to overseas or domestic purchasers.

3) Do not clear cut old growth timber. Lesnoi on Afognak Island has done enough of that, as has SeaAlaska.

4) Tourists and cruise ship customers do not want to see denuded landscapes in SE Alaska. They just don?t.

5) Do not ever let heavy equipment be driven across a salmon stream.

6) Do not ever let trees be denuded right down to salmon banks.

7) Do not decimate the rest of SE the way that Prince of Wales Island has been. I personally told Secty. Vilsack when I met him in the Summer of 2014, that I hoped the USFS lost the litigation related to the Big Thorne harvest. He won, and I lost, apparently.

8) It?s ?o.k.? to say ?no?. It?s ?o.k.?

9) Alaska?s industry is already less than 10% of what it was. Don?t bring it back. The economy has adjusted. Just leave it alone.

10) Future generations will be unimpressed with the amount of wealth and comfort we?ve amassed since the Industrial Revolution. They?ll be more impressed with the natural beauty we protect.

Thanks for listening,

State Rep. Andy Josephson

Juneau, Alaska

VALUES IN ACTION
SEALASKA

February 22, 2016

Mr. Earl Stewart, Forest Supervisor
Tongass National Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, AK 99901

Comments-alaska-tongass@fs.fed.us

RE: Comments on November 2015 Proposed Tongass National Forest Land And Resource Management Plan Amendment and Draft Environmental Impact Statement

Dear Mr. Stewart:

This letter is in response to the November 20, 2015, Federal Register Notice of Availability of the November 2015 Draft Environmental Impact Statement ("EIS") for the proposed Tongass National Forest Land and Resource Management Plan ("Tongass Plan" or "Plan") Amendment ("Amendment"). Thank you for the opportunity to submit comments concerning the Draft EIS and proposed Amendment of the 2008 Tongass Plan regarding a transition to predominantly young growth timber harvest and management, renewable energy, and transportation and utility infrastructure.

A. Background on Sealaska Corporation's Interest in the Tongass Plan

Sealaska Corporation ("Sealaska") is the Alaska Native Regional Corporation for Southeast Alaska, representing more than 22,000 shareholders, predominantly of Tlingit, Haida and Tsimshian descent. The traditional homeland of the Tlingit, Haida and Tsimshian includes what is now the Tongass National Forest. Our people have been stewards of the lands and waters of Southeast Alaska for more than 10,000 years. Through the Alaska Native Claims Settlement Act ("ANCSA"), including the most recent amendments in Public Law 113-291 enacted in December 2014, we are completing the process of selecting and receiving title to roughly 365,000 acres of lands within the region. Thus, we are, at this point, the largest non-federal owner of forest lands in Southeast Alaska. Even as the largest non-federal land owner in the region Sealaska's ownership amounts to less than two percent (2%) of the traditional homeland of the Tlingit, Haida and Tsimshian peoples.

Sealaska is undertaking a transition to second growth timber management on our own lands and as such could offer perspective to public land managers. We have made a commitment to rural communities and to the timber industry to provide a predictable and

Sealaska • One Sealaska Plaza, Suite 400, Juneau, Alaska 99801-1276 • Tel: 907.586.1512 • Fax: 907.586.2304

sustainable level of harvest on an annual basis. To achieve this goal, Sealaska has committed to lowering its cut to forty percent (40%) of historic levels. Although this provides economic challenges, a lower harvest level will create a 20-25 year bridge that allows our business and industry partners to continue viable commerce until a large amount of second growth timber volume is available from both private and public lands. Sealaska cannot create this bridge without an equal or greater commitment from public lands.

Sealaska is a leader in forest products and forest land management as a result of development that we have pursued on our own lands, including young growth/second growth management and marketing. We have been engaged in scientific studies on our lands to determine the best practices for second growth management, habitat restoration, and healthy fish and wildlife populations. Sealaska is also a leader in development of biomass energy use. Together with the Sealaska Heritage Institute, we promote Alaska Native arts and ensure the protection of cultural and historical resources, including sacred sites. Sealaska has been an active participant in Tongass National Forest planning processes since the original Tongass Plan was issued in 1979, as well as additional consensus based efforts to address multiple uses in the Tongass such as the Tongass Futures Roundtable. Sealaska submitted comments and actively participated in the process for revising Forest Service land and resource management planning regulations associated with publication of final revised regulations that took effect in May 2012 (the "2012 Planning Rule").

Sealaska, on behalf of its shareholders, has important interests and concerns regarding federal management actions that can affect planning and management of the Tongass National Forest, Sealaska property, and other lands and waters in Southeast Alaska. Sealaska represents the unique and special relationship that the original human occupants and stewards of Southeast Alaska lands and waters have to these natural resources. We want to ensure that the Forest Service considers Sealaska's unique perspective based on our cultural, social, environmental and economic experience in the region, and our desire to provide due consideration to the needs of future generations in accordance with our core cultural value of *Haa Shuka*.

Sealaska's comments are based on our review, to date, of the Draft EIS and proposed Tongass Plan Amendment documents that have been made available for public review during this comment period, and reflect Sealaska's participation with the Forest Service and other stakeholders in meetings, discussions and through other communications since the issuance of the "Transition Framework" materials in 2010. They also reflect our long-standing, broad participation and interest in Tongass National Forest management. The comments in this letter are by no means exhaustive. At this stage, Sealaska would like to highlight some important points, but we look forward to further participation and collaboration during the EIS/Amendment process, including participation in the Tongass Advisory Committee ("TAC") and any offshoot of the TAC, and continued consultation with the Forest Service and Department of Agriculture officials.

In the comments below, references to the November 2015 Draft EIS for the proposed Amendment are denoted "Draft EIS." References to the November 2015

"Proposed Land and Resources Management Plan" document are to the "track changes" version provided for review, and are denoted "Proposed Plan."

B. General Comments

1. The Proposed Amendment and the Amendment Process

Sealaska has experience in young growth management transition and other components of the proposed Amendment. Subject to the Forest Service adequately addressing the concerns in our comments below, we may be able to generally support a Plan amendment along the lines of the proposed Amendment alternative and recommendations of the TAC, as set out in the TAC December 15, 2015 letter to Secretary Vilsack, Department of Agriculture, and the accompanying December 20-15 TAC Final Recommendations document. We want to express particular support for Forest Service's continued workforce development and training associated with the young growth transition and Plan amendment process, and also efforts towards improved stakeholder collaboration and community involvement in Tongass planning and management. These efforts are exemplified by the Hoonah Partnership co-management initiative, the 2015 Challenge Cost Share Agreement between the Alaska Division of Forestry and the Forest Service regarding further young growth inventory and related work, and by the TAC and the recently formed All Landowners Group.

Sealaska does have strong concerns and questions about the supporting analysis and practical viability of what is proposed for transition to predominant young growth harvest and other elements of the Plan Amendment proposed alternative and Draft EIS, as further described below in this letter. We question the assumptions and adequacy of the analysis in the Draft EIS regarding young growth timber inventory, the supply of timber from Native Corporation and other non-federal lands (which is overstated in the Draft EIS) and other assessments of demand, supply, economics, industry and community needs dependent upon Tongass timber harvest. We also have concerns regarding the need for broader active, realistic, and adaptive management of the Tongass. We also have a general concern that the proposed Amendment is in response to a directive from the Secretary of Agriculture, and is being pushed for completion according to a political timeline that may not yield a viable, sustainable transition amendment.

We also have concerns about use of the 2012 Planning Rule, in comparison with 1982 planning regulation provisions that remain in effect pending eventual revision of the Tongass Plan, in development of the proposed Amendment and in its implementation. These concerns include confusing descriptions in the Proposed Plan and Draft EIS documents regarding which standards and other requirements apply to various components of the Plan once the proposed Amendment would take effect, for purposes of project consistency determinations and other purposes.

Thus, as a general comment and as further explained in the more specific comments below, if the Amendment is going to be finalized in 2016, it should expressly incorporate completion of an updated field inventory of all young growth stands, updated yield/growth models, further review and analysis, and consideration of further subsequent Amendment based on those updated insights. This adaptive management component, which is entirely consistent with the 2012 Planning Rule and TAC recommendations, will

be needed to help assure that the transition timber base, schedule, and other components are economically and socially sustainable and do not result in the loss of the remaining Southeast Alaska forest industry and related community infrastructure over the next several years and beyond.

2. Providing for Alaska Native Interests through Consultation and the Tongass Plan

The final Amendment must provide a framework that accommodates and supports: 1) Tribal and ANCSA Corporation consultation; 2) conveyances of land entitlements pursuant to ANCSA; 3) access to and across national forest lands under Titles VIII and XI and Section 1323 of the Alaska National Interest Lands Conservation Act ("ANILCA") and other laws; 4) cultural and historic site protections; 5) rural resident subsistence hunting, fishing and gathering; and 6) other rights that are essential for Alaska Natives. The final Amendment should also provide for Tribal and Alaska Native Corporation partnership and collaboration with the Forest Service in national forest management. This includes, as part of young growth management transition and other components, providing a framework for entrusting stewardship of appropriate areas of the national forest and related programs to Native Corporations and Tribes, through co-management agreement, contracting and other mechanisms. This also includes Alaska Native Corporation and Tribal participation in management of sites of cultural and historic significance, including sacred sites.

Consultation, coordination and collaboration with Native Corporations and Tribes in planning and implementing national forest management is recognized and required in the 2012 Planning Rule as well as in Executive Order and statute. *See, e.g.*, 36 C.F.R. § 219.4. We are encouraged by Forest Service efforts in the Hoonah Partnership and other initiatives referenced above. Sealaska emphasizes the need for a final Amendment to clearly support continuation and building upon these efforts for successful implementation of young growth transition, renewable energy, transportation, and other components of the Amendment and broader Tongass Plan going forward.

3. Alaska Native Access to and Use of Forest Resources

Our people have lived and thrived here in this region for more than 10,000 years. Our cultural and social survival is dependent upon continued access to and use of the resources within the Tongass National Forest and throughout the region. Continued sustainable subsistence and commercial harvest of resources such as fish, game, berries, bark, monument and totem logs and other resources from the Tongass National Forest and waters by Sealaska's shareholders and other rural residents is important for individual health and community cultural and economic vitality. The Forest Service has recognized the importance of these resources in a video it produced in 2011, entitled "Living off the Land," and also generally in the proposed Amendment Draft EIS analysis of Southeast Alaska communities, subsistence, and other resources.

The final amended Plan must fully and clearly provide for continued subsistence and other sustainable harvest of national forest resources to meet Alaska Native and rural community needs and purposes, including those uses recognized under ANILCA. These uses must not be secondary or slighted in favor of "ecosystem diversity," "sustainable

recreation," or other non-consumptive use or preservation management concepts. Unlike most, if not all, national forests in the lower 48 states, communities throughout Southeast Alaska are largely surrounded by national forest lands, and depend predominantly on resources from the Tongass National Forest for actual survival, not to mention cultural, social and economic vitality. We strongly believe that the economic resiliency of Tongass communities needs to be addressed in appropriate balance with all of the other priorities, as the history of these communities provides significant value to the Tongass and many of these communities remain threatened by lack of economic opportunity.

C. Specific Comments

The following are Sealaska's more specific concerns and other comments at this point regarding the proposed Amendment and Draft EIS documents. These comments are by no means exhaustive and are not listed in any order of priority.

1. Amendment Process

The Proposed Plan and Draft EIS documents are, at minimum, a bit complex and confusing regarding: (1) what elements of the 2012 Planning Rule and which amended Plan components will apply to which areas and activities on the Forest; and (2) how 1982 planning regulations versus the 2012 Planning Rule Forest Plan consistency requirements will apply to implementing projects after the Amendment takes effect. Such confusion could generate substantial disputes, not to mention possible delay in successful implementation and effectiveness of Amendment components. A review of the text discussing these elements and some effort at simplification and clarification is needed at a minimum. *See, e.g.,* Proposed Plan, pp. 1-5 to 1-6 (Introduction), 6-2 (Implementation); Draft EIS, pp. 1-4; 2-3 to 2-4.

The Proposed Plan and Draft EIS documents reference that the Forest Service is engaged in updating the Tongass Monitoring Program to meet 2012 Planning Rule requirements concurrent with the Amendment effort, with a scheduled completion of May 9, 2016, to meet the target date for transition of forest plan monitoring programs under the 2012 Planning Rule ("Monitoring Program"). *See, e.g.,* Proposed Plan, p. 5-4. We understand that a public comment period is being provided for the proposed updated Monitoring Program prior to its finalization, which is essential, but are concerned that this update effort is not being more closely integrated with the Plan Amendment process and that it appears to be on a rushed schedule to meet the May 9, 2016 target date.

The Monitoring Program is an important and required component of adaptive management for the Tongass Plan. The TAC recommendations emphasize this component for a successful young growth transition, and Sealaska believes we can be an important collaborator in monitoring work. We understand that the 2012 Planning Rule establishes May 9, 2016 (four years after the effective date of the Rule) as a target date for updating the Monitoring Program. 36 C.F.R. § 219.12(c). However, some flexibility for exceeding this date is provided for based on practicability under the Rule and implementing Forest Service Handbook ("FSH") Directives. *Id.*; FSH 1909.12 (Chapter 30, Section 32.3, p. 31). Accordingly, we recommend that the Monitoring Program update not be finalized until a final Plan Amendment is issued, to help assure consistency and integration.

2. Young Growth Management Transition Issues

A final Tongass Plan Amendment should ensure that there is due consideration of best practices for the management of young growth forests through silviculture (thinning, pruning, planting) and habitat restoration. These management activities ensure a healthy forest and important habitat for the fish and wildlife resources that our Southeast communities rely upon. These activities also provide employment opportunities in our region.

Another important aspect of young growth management transition is the Forest Service understanding of the economic and market opportunities for young growth forests. A final Amendment should reflect sound review and analysis of available market data and the economic outlook for young growth forest products. This will assure that conclusions and resulting Amendment provisions are based on a realistic assessment of needs and criteria for a market for Southeast Alaska young growth in competition with other sources. It has been our experience that there needs to be a mix of activities in both old growth and young growth stands to ensure a viable timber program as well as to meet cultural and subsistence use needs and ecological management objectives.

In this context, the proposed Amendment alternative along with the TAC recommendations for implementation have the potential to provide a basis for an improved transition to a predominantly young growth timber base and sale program compared to the current Plan. Notable elements with merit, in addition to the overall collaborative stakeholder process and framework, are: 1) making portions of beach fringe, riparian, and old growth habitat and reserve "LUD" areas available for young growth timber supply and management; 2) requirements to offset further losses to the timber base due to increased set-aside or restriction of areas from harvest with addition of areas to be available for harvest (i.e. no net loss of young growth acres of timber base); 3) retaining at least some sustained old growth harvest going forward under a predominant rather than exclusively young growth harvest approach; and 4) provisions for monitoring and adaptive management. However, we have concerns about the supporting analysis, aggressive schedule, and other parameters of the proposed Amendment, as further described below.

The proposed Amendment and Draft EIS substantially overestimate the timber supply from non-federal lands, which makes their conclusions about adequacy of Tongass supply from the proposed amendment action alternatives erroneously low. Harvest from Sealaska lands, the primary source of private land timber in Southeast Alaska, will average less than a maximum of 45 million board feet ("mmbf") per year for at least the next 20-25 years, and Village Corporation lands harvest will be far less during that time period. Yet despite Sealaska representatives making recent and projected future harvest information available throughout the Amendment process to the Forest Service and TAC, the Draft EIS and supporting draft Tongass timber demand study assume a reliable Native Corporation land supply of up to 80 mmbf per year during the next 15 years. *See, e.g.* Draft EIS, p. 3-314 (Table 3.13-12); Jean Daniels, Michael Paruszkiewicz, Susan Alexander, Tongass National Forest Demand, Projections for 2015 to 2030, pp. 51, 54 (Tables 12 and 15) (manuscript in preparation-December 2, 2015) available at http://www.fs.fed.us/pnw/pubs/draft/Tongass-Timber-Demand-Draft.pdf

(hereinafter "Daniels"). This number is too high and it is not clear where this number came from.

Furthermore, for purposes of estimating demand for Tongass National Forest Timber, the proposed Amendment and Draft EIS treat the demand as a "residual" amount to make up any shortfall in meeting projected overall demand from State, Native Corporation and other non-federal timber sources. *See. e.g.*, Draft EIS, Appendix G, p. G-4; Daniels, p. 14. This "residual" approach also incorporates lower Tongass harvest trends from recent years, without apparently attributing the low figures to the existing Plan restrictions that limit Tongass harvest to a timber base area that is a very small portion of Tongass commercial forest lands and impose high costs on that harvest, not to mention the numerous appeals and litigation that have denied or delayed Tongass harvest over this time period. *See, e.g.*, Daniels, pp. 31-32. The demand/supply projections appear to have been reached without regard to whether, absent those restrictions and challenges, or the related loss of Southeast Alaska forest industry infrastructure, there would be a demand for more timber. This analysis strikes us as circular and inconsistent with basic national forest multiple-use sustained-yield purposes, Tongass Timber Reform Act direction to seek to meet market demand for Tongass timber, and also meeting Southeast Alaska community economic and social sustainability needs, which should be on an equal footing with ecosystem sustainability.

Sealaska itself has a publicly known interest in approximately 20 mmbf per year of Tongass timber that it can harvest and process or sell to complement and provide better economies of scale for timber operations on its own lands. This is a demand factor above and beyond what is needed to more fully and cost-effectively operate existing Southeast Alaska mills and for other operators. At the least, this 20 mmbf per year should be added to the projections of demand for Tongass timber.

With respect to old growth harvest, there will be a continued need for a reasonable amount of old growth harvest for various commercial as well as cultural (canoe and monument or totem logs; other Alaska Native arts, etc.) and subsistence uses. The proposed Amendment and other action alternatives in the Draft EIS provide no more than 5 mmbf per year of old growth harvest after the first 15-16 years of transition, limited to very small sales. But the Draft EIS confirms that young growth harvest sales will appraise negatively and require federal subsidies unless combined with sufficient old growth volume to generate a positive economic return, for at least the first couple of decades of transition. *See, e.g.*, Draft EIS, p. 3-481.

We believe more old growth harvest can and should be accommodated to meet market demand for higher-grade, higher value and in many cases unique commercial products, as well as Alaska Native art and culture and other uses, without compromising the preservation of old-growth ecosystems over the majority of the Tongass. Each of the alternatives regarding timber harvest evaluated in the Draft EIS would limit Tongass timber sale volume to a fraction of the "Sustained Yield Limit" that the Forest Service indicates the Tongass is capable of producing sustainably into perpetuity, leaving more than ample room for considering substantial additional timber sale and harvest volume for the transition period and beyond. *See, e.g.* Draft EIS, p. 3-311. As acknowledged in the Draft EIS, providing more timber sale supply than market demand year to year and providing a reliable "pipeline" of Tongass timber is preferable to under-supplying the

market, given the financially devastating effects of a significant shortfall in supply to the remnants of the Southeast Alaska forest industry and infrastructure. Draft EIS, Appendix G, p. G-8.

Simply put, the final Amendment regarding a transition to predominantly young growth harvest can and should focus on management of the small portion of the Tongass that has been previously harvested, but it should not dictate hard limits on or preclude old growth management and harvest on the larger area of the Tongass that can remain available for timber sales and active management. Contrary to what the Draft EIS indicates, old growth is a renewable resource and old growth areas can be managed for timber production as well as wildlife habitat and other benefits, using 150 year or longer rotations, thinning, and other best practices.

As indicated in the more general comments above, the Forest Service is basing its aggressive young growth transition proposal on incomplete and unreliable forest inventory data and other information, in an apparent rush to complete the Plan Amendment in response to political directives. Our review as well as those of others indicate that the agency's young timber growth/yield model significantly overstates timber yield and volumes, being based largely on field data from some older, lower elevation and relatively high site quality stands.

The proposed Amendment may also be relying too much on assumptions about increased future yields and returns from "commercial thinning". *See, e.g.,* Draft EIS, p. 3-303. Sealaska's experience with commercial thinning on its own lands to date indicate that wind-throw and other damage to the remaining trees and other factors render it very questionable as an economically and silviculturally sound practice on a substantial scale in Southeast Alaska forests.

The analysis in the Draft EIS of the feasibility of manufacturing products in Southeast Alaska or exporting logs from young growth is questionable in other ways; the factors that we believe need further analysis include:

- Costs of accessing and harvesting young growth stands;
- Low values of young growth lumber;
- Lack of economies of scale (small size of the remaining industry and the supply of timber projected);
- Related lack of assurances/incentives to support investment to grow and adapt to an infrastructure that can be sustained with predominant young growth harvest;
- Assumptions and overestimates regarding the amount of non-federal timber that will be available to local mills;
- Assumptions about the economics of and demand for utility logs for biomass energy or other uses and availability of such logs;

- Assumptions about the pace at which the Forest Service can make viable timber sales available and the economic volume that can be made available, given Plan restrictions as well as National Environmental Policy Act ("NEPA") process, appeals, litigation and other delays and costs.

Accordingly, the Amendment decision should not be finalized until updated and complete stand-level young growth field inventory information and young growth yield models are completed, and additional review and analysis covering at least the concerns described above is conducted. If the proposed Amendment is adopted before that time, affirmative provision for early review and consideration of further amendment once updated information and analysis is available should be expressly incorporated in the Amendment, as sound adaptive management and to help assure that the Southeast Alaska forest industry and our communities are not locked into a flawed transition strategy and pace that will end in failure.

The Forest Service should in any case expedite the needed field inventory and other work. This is also an opportunity to provide contracting and other employment for Native Corporations and their shareholders and other local businesses and citizens, as well as essential information for continued Tongass National Forest planning and management.

3. Coordinating Resource Management and Harvesting with Adjacent Landowners

The amended Plan should provide for the Forest Service to coordinate its resource harvest and other management activities with adjacent landowners - Sealaska, along with village corporations, the State of Alaska, the University of Alaska and the Mental Health Trust, in particular. This coordination of activities could result in significant savings related to resource and financial costs. For example, Sealaska and the Forest Service could pursue young growth harvest in the same vicinity, which could allow the two property owners to share road maintenance costs, contractors, log transfer facility ("LTF") costs, and so forth. The final Amendment should be clear, however, that Tongass National Forest management or control does not extend to Sealaska or other non-federal lands.

There does not appear to be much in the Proposed Plan or Draft EIS documents regarding such coordination. Pursuant to 36 C.F.R. § 219.4, please consider adding more express emphasis on landowner coordination as part of Plan direction for timber, transportation, renewable energy and in the implementation chapter of the Plan. The Hoonah Partnership, existing road cost-share agreements, and other particular examples are available as templates for further coordination agreements. The All Landowners Group and the Tongass Transition Collaborative ("TTC"), which have begun meeting as an outgrowth of TAC recommendations, may be useful mechanisms for facilitating coordination and collaboration going forward.

4. Roadless Rule and Road Access Issues

The varied treatment and application of the Roadless Rule in the Tongass National Forest since 2001 have resulted in uncertainty and barriers to development in

Southeast Alaska. The amended Plan should provide clarity and allow for removal of barriers to management and development that exist as a result of the Roadless Rule and that are not required by court decisions. The final Amendment should allow for further road access for not only timber, mineral and energy uses, but also access to resources important to the residents of the region for subsistence, recreation and other community economic, cultural, and social activities.

We are concerned that the proposed Amendment and Draft EIS alternatives treat all current inventoried roadless areas as generally unavailable for further road access or development. The final Amendment should at least affirmatively and clearly provide for further review and Plan amendment once current litigation is resolved or the current 2001 Roadless Rule application to the Tongass is otherwise changed through Congressional action or further rulemaking. Treating all inventoried roadless areas as off-limits to new roads other than the limited exceptions provided in the 2001 Roadless Rule is particularly and unnecessarily restrictive on the uniquely large and undeveloped Tongass.

As a particular comment, a minor edit of text in the Proposed Plan is warranted. On page 5-17 of the Proposed Plan, simply reword the roads objective (G-TRAN-01) to clarify and confirm that some new road construction and reconstruction will be allowed during the first 15 years after an amended Plan takes effect, by adding "construct, reconstruct" in front of "manage and maintain . . . ."

5. Renewable Energy Development

Sealaska supports the apparent increased flexibility for energy facilities and infrastructure included in the proposed Amendment. Developing and implementing alternatives to diesel generation and other measures to reduce the high costs of power in rural Southeast Alaska communities is imperative. That flexibility in the final Amendment should encompass additional hydroelectric energy development and interconnections for this proven, plentiful, reliable source of renewable power in Southeast Alaska, as well as geothermal, biomass and other alternative or renewable energy opportunities.

Road access to energy development and delivery sites, as addressed above, is an important aspect of realizing further cost-effective energy gains. Requiring helicopter rather than less costly access needs to be limited to where it is clearly legally mandated or otherwise the only practicable means. There should be additional flexibility in the final Amendment to help ensure consistency with federal energy policy that supports all forms of renewable energy development, and associated transmission lines.

Sealaska will continue to support and lead viable biomass energy development in Southeast Alaska, and looks forward to working with the Forest Service and other stakeholders in that effort. We are concerned, however that the proposed Amendment and Draft EIS analysis presumes under at least some scenarios a large increase in biomass energy production in Southeast Alaska within a timeframe that may not be feasible or realistic. Draft EIS, Appendix G, p. G-5; Daniels, p. 27-29. In particular, Tongass timber program young growth transition utility log supply/demand forecasts and other analysis should not rely on that presumption.

6. Fish and Wildlife Resource Research and Management

The amended Plan and associated updated Monitoring Program should provide for use of the best objective methods and processes for monitoring, researching and sustaining fish and wildlife resources in the forest. As the Forest Service is well aware, the communities in Southeast Alaska are dependent on these resources physically, culturally, socially and economically. Sealaska is particularly concerned about the monitoring, research and protective and sustainable management of our subsistence resources, including but not limited to salmon and deer.

Such management can be completely consistent and compatible with a working, multiple use national forest that sustains viable timber, fishing, mineral, energy, and other commercial uses and prosperous, stable communities and family-supporting local employment. Sealaska has been and plans to continue to be a source of sound scientific, technical and professional studies, reports and other insights regarding thinning, riparian best management practices, and other measures to benefit fish and wildlife populations, while also obtaining sustainable wood and other products from Southeast Alaska forests. We hope to continue to collaborate with the Forest Service, State, and other landowners, as well as other experts and professionals in this arena.

We note that the final Amendment and EIS documents should be updated to reflect the recently published U.S. Fish and Wildlife Service determinations that Prince of Wales Island and other Alexander Archipelago wolf populations are not a distinct population segment under the Endangered Species Act ("ESA"), and that listing these populations as endangered or threatened under the ESA is not warranted at this time. 81 Fed. Reg. 435-458 (Jan. 6, 2016).

7. Subsistence – Resources and Access

We note that the Proposed Plan and Draft EIS documents do recognize and address Southeast Alaska community and citizen subsistence resources, uses and needs at some length. Pursuant to ANCSA, ANILCA, 36 C.F.R. § 219.4 and other requirements, we ask that the Forest Service assure that there is clear emphasis on providing for Alaska Native access to and use of subsistence resources throughout the Tongass in all components of the amended Plan.

As a more particular comment, Section 3.2 of the Proposed Plan requires the Forest Service in project scoping to include contact with various agencies, tribal governments and other entities, but omits Native Corporations from the list. Proposed Plan, p. 4-68 (Subsistence Forest-Wide Standards and Guidelines). Please correct to read: ". . . include initial and ongoing contact with the appropriate federal and state agencies, local committees, recognized tribal governments <u>and Native Corporations</u>, and the Southeast Alaska Federal Subsistence Regional Advisory Council." Additionally, please review the Proposed Plan document for other instances where Native Corporations should be added to lists of entities to be consulted or coordinated with regarding subsistence as well as other issues and resources, pursuant to 36 C.F.R. § 219.4 and other requirements.

The Proposed Plan at page 4-68 also appears to contain some other wording and punctuation gaps in the text. We recommend that the agency review and correct any typographical or other errors in this section.

8. Sealaska Land Entitlement Legislation

We note that the Forest Service has referenced and recognized in the Draft EIS the enactment of the Sealaska land legislation in Public Law 113-291 and related ownership adjustments that impact Forest Service ownership of timber resources. Draft EIS, pp. 1-5 to 1-6, 2-9, 3-265 to 3-270, Appendix C (Cumulative Effects), Appendix E (Interagency Old-Growth Reserve review). However, the Draft EIS and proposed Amendment do not appear to also evaluate or reflect in any detail the approximate 150,000 acres of additional Congressional LUD II designations included in the statute and their attendant protective old growth and natural ecosystem benefits or other effects. The Draft EIS and proposed Amendment likewise do not appear to address or reflect the benefits of the release in the statute of approximately 300,000 acres of Tongass lands previously withdrawn for selection by Sealaska under ANCSA. Draft EIS, pp. 267, 269. Although some of these lands may remain subject to completion of Village Corporation conveyances, they are now free from the restrictions and uncertainty regarding potential selection by and conveyance to Sealaska. Pub. L. No. 113-291, § 3002(b)(3)(ii). Most or all of these previously withdrawn lands are now or soon will be unencumbered and available for timber and other national forest management and uses.

Please assure that these changes are adequately evaluated in the EIS and reflected in young growth transition and other components of the Amendment prior to finalizing and completing the Amendment process. The process should include appropriate opportunity for comments by other agencies, Sealaska and other stakeholders, and the general public.

9. Unfulfilled Native Land Entitlements

We appreciate that the Forest Service in the Draft EIS has included some recognition and consideration of other unfulfilled Native land entitlements, including the five unrecognized or "landless" communities that continue to seek inclusion in ANCSA and compensation through land allocations in Southeast Alaska; and Alaska Native veterans who have sought Native allotments in Southeast Alaska but who continue to be denied this opportunity because of the current land allocations and designations in the region. Draft EIS, p. 3-265. These continue to be important outstanding issues; the amended Plan should recognize and account for them as outstanding and allow for their resolution in the future.

10. Other

Proposed Plan, page 1-2 - The text on this page analogizing a forest plan to municipal zoning ordinances is inaccurate and misleading with respect to the National Forest Management Act ("NFMA") multiple-use legal framework for national forest planning and management. The proposed text appears to emphasize separating rather than reasonably mixing uses by area, and may suggest priority for protection of resources rather than a balance with economic and social sustainability of communities in the

region. The analogy appears to be to urban community zoning, which itself is evolving into much more mixed-use districts and flexibility, recognizing the diversity and other socioeconomic advantages of less rigid separation and uniformity of uses. The single use land allocation concept is even less apt for rural area zoning, which often allows a wide range of uses within a general rural zone via a special or conditional use permit individual application and review process. In any case, any analogy between multiple-use, working national forest land and resource management planning under federal law and local government zoning is rough at best. Please correct this text accordingly.

Proposed Plan, page 4-70 - References to "Allowable Sale Quantity" ("ASQ") are deleted on this page and otherwise in the Plan. We understand that ASQ is being replaced with "Sustained Yield Limit" ("SYL") as defined in the Proposed Plan Glossary at page 7-74 and further described in the Draft EIS in relation to the Projected Timber Sale Quantity" ("PTSQ"). *See, e.g.*, Draft EIS, p. 3-311. We understand that these changes are related to updated direction in the Forest Service Handbook for implementing the 2012 Planning Rule. *See, e.g.* FSH 1909.12 (Chapter 60, Section 64.3 , and Subsections 64-31-64.32). We note that the NFMA requires a limit on the sustained-yield quantity of timber that may be sold from each national forest, and the 2012 Planning Rule does not appear to require a different term than ASQ to be used for this purpose. *See* 16 U.S.C. § 1611; 36 C.F.R. § 219.11(d)(6), respectively. It would be helpful at the least for the final amended Plan and EIS to include further explanation and cross-referencing to the Handbook to clearly delineate any substantive, as well as terminology changes involved with respect to ASQ versus SYL and PTSQ as used in the Amendment documents.

Proposed Plan, page 4-74 - Utilization standards, wind-throw and other direction from the current Plan have been deleted here; the extent and location of any replacement or other updated direction is unclear. We understand that utilization standards need not be included as enforceable forest plan "standards" within the meaning of the 2012 Planning Rule. However, a forest plan is still required to identify or reference the utilization standards that saw timber, pulpwood, and other standard forest products must meet for purposes of inclusion in the PTSQ and other calculations of volume quantities in the plan. FSH 1909.12 (Chapter 60, Section 64.34). These utilization standards are otherwise important for ongoing Tongass planning and management as well as review of the proposed Amendment and Draft EIS documents. Additional, clear explanation and cross-reference regarding the deletion of utilization standards and similar content from the Plan document and identification of the current utilization standards and any other updated direction or criteria would be helpful.

Proposed Plan, page 6-1 - This page states that a Tongass Plan annual program of work is explained in Appendix J, but Appendix J is apparently deleted from the Proposed Plan document and no longer included. Please correct or clarify.

Proposed Plan, Chapter 7 (Glossary) (also referenced in the Draft EIS, Appendix A) - This section in particular could benefit from further careful review, proofreading, and editing to shorten, clarify and correct its content. There are some apparent clear errors, such as:

- The definition for "Administrative Use (timber)" appears to repeat the definition for the word "adjacent." Proposed Plan, p. 7-2.

- The definition for "Categorical Exclusion" appears to repeat the definition for "Environmental Document." Proposed Plan, p. 7-10.

- The definition for "Commercial Timber" appears to be missing the word "that" between "lands" and "may" in the first line. Proposed Plan, p. 7-12.

- The definition of "Significant Effect" appears to be comprised of text describing second growth forest. Proposed Plan, p. 7-85. Note also that since "significant effect" is a term of art under NEPA and its meaning may vary in other contexts, a definition for this term is probably best omitted from a forest plan glossary.

There are also many terms in the Glossary for which a second definition has been added that appears largely redundant to the first definition or which otherwise may be confusing. See for example the definition of "Smolt."

Also, there are terms in the Glossary that include an acronym that does not necessarily need a definition and which could be addressed in a much simpler acronym table or index. See for example the listing of "Code of Federal Regulations ("CFR") followed by a lengthy description of the CFR. Proposed Plan, p. 7-12.

D. Closing Comments

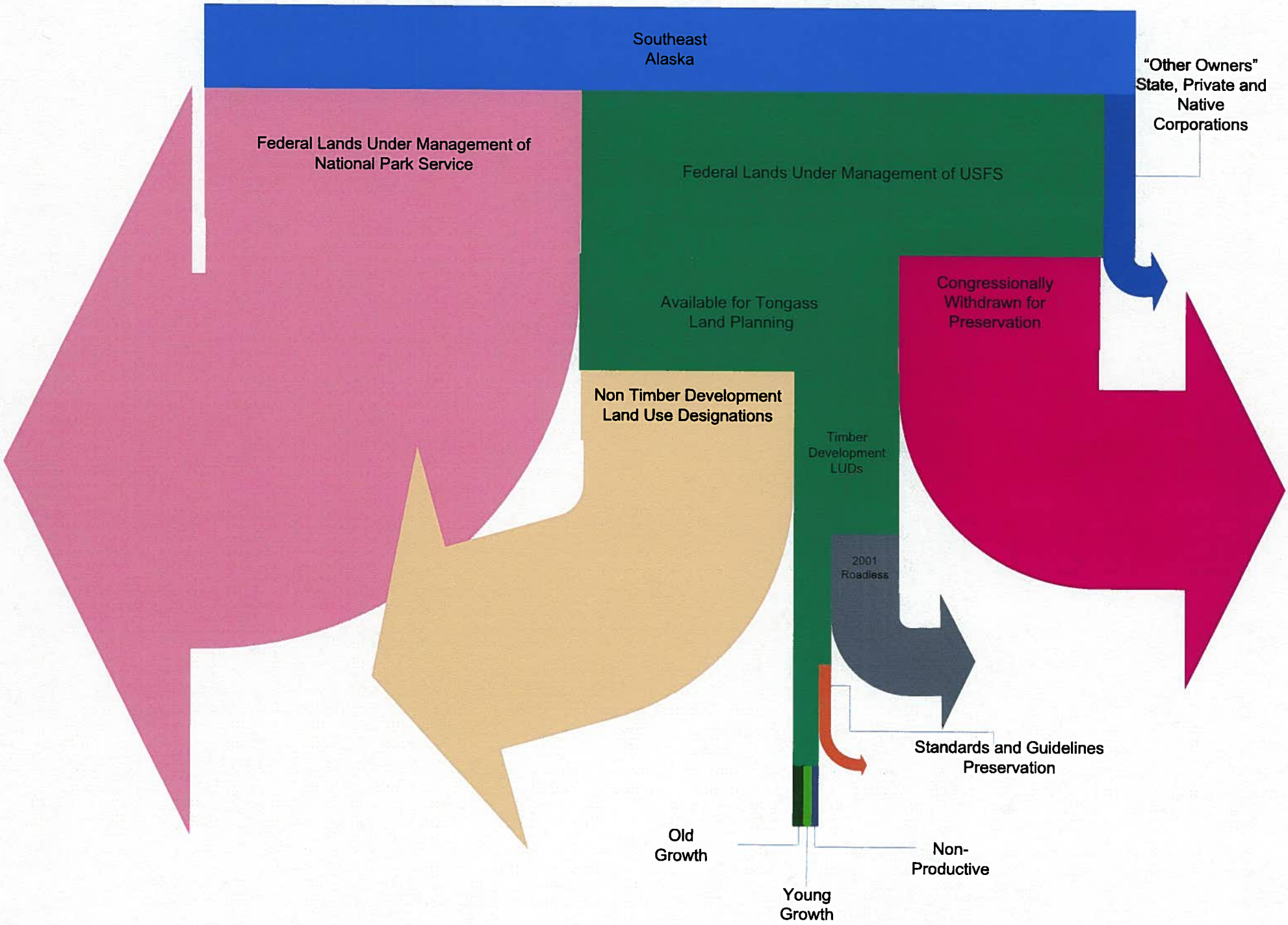
On behalf of our 22,000 shareholders and our impacted Southeast Alaska communities that are home to our shareholder base, thank you for the opportunity to submit comments concerning the Draft EIS and proposed Amendment to the 2008 Tongass National Forest Plan regarding young growth management transition and other issues. We hope that you will consider and be responsive to the comments incorporated in this letter, and we look forward to continued dialogue and collaboration as the Forest Service continues the Amendment process and beyond, through implementation.

Sincerely,
SEALASKA CORPORATION

Anthony Mallott
President & Chief Executive Officer

Attachment

Southeast Alaska Lands and Preservation Status



LISA MURKOWSKI
ALASKA

COMMITTEES:
ENERGY AND NATURAL RESOURCES
CHAIRMAN

APPROPRIATIONS
SUBCOMMITTEE ON INTERIOR, ENVIRONMENT, AND RELATED AGENCIES
CHAIRMAN

HEALTH, EDUCATION, LABOR, AND PENSIONS

INDIAN AFFAIRS

United States Senate

WASHINGTON, DC 20510-0203
(202) 224-6665
(202) 224-5301 FAX

510 L STREET, SUITE 600
ANCHORAGE, AK 99501-1956
(907) 271-3735

101 12TH AVENUE, ROOM 329
FAIRBANKS, AK 99701-6278
(907) 456-0233

800 GLACIER AVENUE, SUITE 101
JUNEAU, AK 99801
(907) 586-7277

805 FRONTAGE ROAD, SUITE 105
KENAI, AK 99611-9104
(907) 283-5808

1900 FIRST AVENUE, SUITE 225
KETCHIKAN, AK 99901-6059
(907) 225-6880

851 EAST WESTPOINT DRIVE, SUITE 307
WASILLA, AK 99654-7142
(907) 376-7665

February 19, 2016

By Electronic Mail and U.S. Mail
Mr. Earl Stewart, Forest Supervisor
Tongass National Forest,
Attn: Forest Plan Amendment
648 Mission St.
Ketchikan, Alaska 99901
Comments-alaska-tongass@fs.fed.us

RE: Comments on Proposed Land Resource Management Plan for the Tongass National Forest, November 2015, R10-MB-769 a-c.

Dear Mr. Stewart:

Attached for inclusion in the referenced docket are my Comments on the *Proposed Land Resource Management Plan for the Tongass National Forest, November 2015* .

Sincerely,

Lisa Murkowski,
United States Senator

Cc: Robert Bonnie, U.S. Department of Agriculture
Beth Pendleton, Tongass Regional Forester

Formal Comments of
Senator Lisa Murkowski on the

Tongass National Forest:
Proposed Land and Resource Management Plan (2015)

R10-MB-769 a-c

Submitted February 19, 2016

Submitted to:
Mr. Earl Stewart, Forest Supervisor
Tongass National Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, AK 99901

Submitted by:
Senator Lisa Murkowski
709 Hart Senate Building
Washington, D.C. 20510
202-224-6665

INTRODUCTION:

I write to express my views on the *Tongass National Forest: Proposed Land and Resource Management Plan (2015)* (Proposed TLMP, Plan or Plan Amendment) and the U.S. Forest Service's (Forest Service) Proposed Preferred Alternative changing the 2008 *Tongass National Forest: Land and Resource Management Plan* (Final TLMP, or 2008 Plan)[1] released for comment on November 15, 2015.[2] The three-volume Plan prompts a host of conflicting reactions. The updated scientific research and data collected by Forest Supervisor Earl Stewart, Project Team Leader Susan Howle, and their 20 assistant "preparers" and 46 "contributors" is impressive. Unfortunately however, as detailed in these comments, the substance of the Plan is deeply concerning. The Forest Service should wait to make a final decision on whether and what kind of TLMP plan update is required until there is firm data to support the Administration's policy decision to accelerate a transition to a young-growth forest management program in the region.

As an Alaskan born in Southeast Alaska, some of the research was fascinating. For example, it is notable that El Capitan Cave on Prince of Wales Island is between 107,000 and 115,000 years old.[3] It is useful to know that there are 152,800 acres of Productive Old-Growth timber (POG, the largest of old-growth trees) on top of karst formations remaining in the Tongass;[4] that since Statehood Alaskans have harvested only 8 percent of the original POG in the Tongass Forest; and that, regardless of which proposed alternative is selected to govern future forest activities, 91 percent of all POG will remain after a century.[5]

The detailed accounting of land ownership is very useful especially because it documents conclusively that only 190,000 acres of the 17,906,000 acres of total land within the outer boundaries of the Tongass National Forest are privately owned. It is important to keep at the forefront the fact that the Forest Service controls 93.4 percent of the forest or 16,720,000 acres after passage of the *Southeast Alaska Native Land Entitlement Finalization Act* (Sealaska Lands Bill) in December 2014.[6] Only one-half of one percent of the forested lands in Southeast Alaska contain 2 miles of road per square mile, while 46 percent of the nearly 18 million acres have no roads at all, another fact contained in the Plan that bears emphasis.

Unfortunately, despite its positive attributes, overall the Plan is unjustified – a extremely premature attempt to implement a legally questionable, economically unsupported, environmentally unneeded, and extremely short-sighted change in the management of the nation's largest federally owned forest.

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[1] U.S. Department of Agriculture Forest Service, *Tongass National Forest: Land and Resource Management Plan* (2008), available at https://fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5367422.pdf.

[2] U.S. Department of Agriculture Forest Service, *Tongass National Forest: Proposed Land and Resource Management Plan* (2015), available at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd480655.pdf.

[3] U.S. Department of Agriculture Forest Service, *Tongass Land and Resource Management Plan: Draft Environmental Impact Statement – Plan Amendment*, 3-27 (November 2015), available at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd480660.pdf.

[4] *Id.* at 3-28.

[5] *Id.* at 2-40.

[6] *Id.* at 3-263.

THE DRIVER BEHIND A PLAN UPDATE – The Proposed Plan is not driven by actual data, but assumptions to support an agenda to end old-growth harvesting or to satisfy the desire of some to end most all timber production from the Tongass. This Plan Amendment is a rush to judgment that is ill considered and is likely to result in harm to the residents of Southeast Alaska.

The Obama Administration and Secretary Vilsack, soon after taking office in 2009, made it abundantly clear that they intended to dramatically alter the economic underpinnings of the timber industry in Southeast Alaska – an industry that the Forest Service was largely responsible for establishing in the 1950s and that the federal government has been partially responsible for seeing decline in recent decades. In the Secretary's July 1, 2013 memorandum *Addressing Sustainable Forestry in Southeast Alaska* (the Memorandum) he simply decreed that management of the forest would change notwithstanding Congressional direction in 1980, and clarifying direction in 1990 and again in 2014 that requires the Forest Service "to seek to meet" the existing demand for timber (once defined by average timber market conditions, not by Forest Service policy)[7].[8] He did so seemingly because he believed an industry that utilized a tiny percentage of the old-growth trees in the forest somehow violated the *Multiple-Use Sustained Yield Act of 1960* (the 1960 Act). As I see it, he also decided that it simply wasn't worth the cost and time for his agency to address litigation from environmental groups opposed to most any form and any significant quantity of Tongass timber harvesting.

The 1960 Act, even as revised in 1996, requires the Secretary to manage "all the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions…."[9] Clearly under the Act, national forests are to be managed to support recreation, wildlife, economic activities, *and timber harvesting* – a specific designated use in national forests.[10]

The Memorandum, however, equated the desires of some for "changing needs" to timber preservation and a reduction of timber harvesting. Meanwhile, it ignores that "changing needs" in the minds of many Alaskans may well mean the need for greater economic benefits from Alaska's renewable national forest lands as income to offset declines from wealth devised from the production of oil and gas in other parts of the State. The Memorandum seemingly defines timber harvesting in Alaska as, after a transition period, largely equating only to the harvesting of small diameter, young-growth timber (Y-G). This was clearly never intended by Congress in passage of the 1960 Act, the *1980 Alaska National Interest Lands Conservation Act*, or the *1990 Tongass Timber Reform Act*.

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[7] Tongass Timber Reforms Act, Pub. L. No. 101-626 §101 (amending § 705(a) of the Alaska National Interest Lands Conservation Act of 1980 (Pub. L. No. 96-487)).

[8] U.S. Department of Agriculture, *Secretary's Memorandum 1044-009*, 1 (July 2015), available at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5445760.pdf.

[9] Multiple-Use Sustained Yield Act of 1960, Pub. L. No. 86-517 § 4(a).

[10] *Id.* § 1.

The Memorandum calls for a transition to young-growth harvesting over a "10 to 15 year" period, with the possibility of a "small sale program" to harvest a small amount of old-growth timber for "niche markets" after transition.[11] A fatal flaw in this approach is that it sets in motion a transition to young-growth harvesting without any real evidence, but only speculation that such an industry could be economically viable in Southeast Alaska. There is little, if any, firm knowledge of the amount of young-growth that will be environmentally acceptable to harvest from the Tongass. Nevertheless, this information is a primary condition before any enterprise, let alone an industry, could attract the private financing necessary to fund the transition to Y-G. The Administration pressed the transition to Y-G without any clear indication of what end uses would constitute the economic market for Y-G – what products can be made and profitably shipped and sold from the wood in this forest. This transition mandate came before there was any evidence on the economic impacts on the region of the policy shift, an apparent violation of the *National Forest Management Act of 1976*.[12] That Act requires planning *before* policy changes were crafted, not afterwards to justify the actions already directed by the memorandum and the views of political appointees.

The Department and the Forest Service clearly placed the cart before the horse in 2013. It created a Tongass (Citizens) Advisory Committee (TAC) in fall 2013 to make recommendations on *how* the transition could be implemented, leaving out of its charter a discussion on whether such a shift *should* take place.[13] The Administration since then has proposed the Plan Amendment to accelerate the transition to a young-growth industry. The Proposed TLMP picks and chooses which of the advisory committee recommendations to implement, apparently supporting only the recommendations that will allow it to "lock in" a transition plan prior to January 20, 2017.

This Plan Amendment is a rush to judgment that is ill considered, and is likely to result in harm to the residents of Southeast Alaska.

Let me acknowledge that for more than five decades it has been the common wisdom in the region – an area the size of West Virginia – that eventually the timber industry in the Tongass National Forest will transition from dependence on old-growth timber to largely young-growth timber. That was the justification for the expenditure of federal funds to help pay for forest road building in Southeast Alaska. The roads were an investment that would be repaid with stumpage fees and tax revenues from future second- and third- rotation sales and the economic activity they would promote. It makes perfectly good environmental sense to protect a majority of the old-growth timber stands in the Tongass National Forest, to protect fishery habitat and to protect wildlife, both for their own sake and the sake of subsistence, recreational, and commercial hunting in the region.[14] It is wise to encourage an industry to transition and to develop new markets for young-growth timber – markets where Alaskan timber might have economic advantages in sales in the future because of geographical location, product characteristics, or innovations. By contrast, it is arbitrary to set an end date, or effectively arbitrarily limit the amount of old-growth by volume or acreage that may be harvested in the Tongass, without any

[11] USDA, *Secretary's Memorandum 1044-009*, 2.

[12] Pub. L. No. 94-588.

[13] If the latter had been under discussion there likely would have been no recommendations issued by the TAC given the requirements for issuance of a report under the Federal Advisory Committee Act.

[14] 80% of which will be protected even without a young-growth transition plan.

firm evidence that a transition to a young-growth timber supply is economically viable over an articulated time period – whether the transition is viable starting within a few years and fully completed within 16 years, compared to one starting in 25 years and fully underway three decades from now when the existing old-growth will have increased by 50 percent and the acreage to support a future industry 60 to 90 years later will have increased.[15]

It would be counterproductive effectively to place an arbitrary limit on old-growth timber sales of approximately 5 million board feet a year after a "transition," with no evidence that that is a sufficient harvest to meet high-value wood demand for musical instruments or other high-value uses. Such a limit appears to be based on environmental goals rather than a serious consideration of economic facts. It is also wrong to limit arbitrarily the amount of old-growth timber that can be harvested to about 2 percent of a 16.7-million-acre forest, when a harvest that would still leave about 96 percent of such trees standing can occur while enabling a viable, integrated timber industry in the region.[16]

The Memorandum paid lip-service to maintaining a viable timber industry in the Tongass:

> "(The) Department of Agriculture is committed to maintaining Southeast Alaska's exceptional natural resources in perpetuity. USDA is equally committed to doing its part to ensure that the communities within and adjacent to the Tongass National Forest are economically vibrant. These two goals must go hand in hand. ...We must speed the transition away from old-growth timber (but) we must do this in a way that preserves a viable timber industry that provides jobs and opportunities for residents of Southeast Alaska....To accomplish the transition to a timber program based primarily on young growth, it is important to retain the experience and infrastructure of the existing industry so businesses can quickly retool. These businesses are fundamental to both the young growth and restoration components of the future timber program, and to the economic vitality of the region. Such an approach requires a reliable supply of economically viable timber, with the old-growth component decreasing over time while the young growth component increases. ... Additional research will be necessary to develop effective ways to meet" the challenges of establishing an "economically viable young-growth program due to the relatively young age of the available stands, market conditions, and other factors." [17]

The Forest Service should actually fund and undertake that research to make sure that a transition is economically feasible and somewhat likely to succeed *before* amending the 2008 Plan and "locking in" reduced old-growth timber harvest offerings.

As noted above, there is a case to be made for a transition when the amount of second-growth and its volume of fiber make economic sense to support a viable timber industry. In 2014, I accepted a provision to allow a limited waiver of federal law to permit a limited amount of

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[15] Alaska Forest Association, *Comments on U.S. Forest Service Tongass National Forest Timber Demand, Projections for 2015 to 2030*, 7 (January 7, 2016).

[16] USDA, *Tongass National Forest: Land and Resource Management Plan.*

[17] citation

timber to be harvested before it reaches optimal size to allow a transition to begin more quickly.[18] In 2015, I supported the Forest Service's budget to help it gain funding to conduct needed research to prove that there will be sufficient second-growth wood to fuel a young-growth timber industry. I am willing to support additional funding if proposed by the Administration for objective economic studies to determine what products can be made from young-growth and at what costs, to prove the economic viability of a transition given Tongass wood volumes, and to allow private investment to help fund a transition to a young-growth industry. I will support the TAC recommendations for new management policies to allow a transition to young-growth. But the TAC carefully proposed in its recommendations that young-growth replace old-growth on a "one-to-one volumetric basis,"[19] with old-growth not being reduced until there is a market for young-growth to profitably replace it, i.e., until it is proven in an intellectually honest fashion that such a transition can actually take place without further harm to the economic underpinnings of Southeast Alaska's economy and not until there are markets for young-growth to replace the economic benefits of old-growth timber. If objective studies prove that a transition can occur more quickly and be financeable by the private sector it could well be worthy of support.

Until then, I must adamantly oppose unnatural transition, and worse an amendment to the 2008 Plan, that encourages Forest Service management policies that will result in a reduced timber harvest. The Proposed TLMP is not driven by actual data, but assumptions to support an agenda to end old-growth harvesting or to satisfy the desire of some to end most all timber production from the Tongass. This history of timber harvesting in Southeast Alaska provides an important foundation to understand my concerns.

TIMBER HARVESTING HISTORY: Timber sale levels have declined dramatically for more than a decade resulting in the loss of more than 5,000 timber and timber-related jobs.

The blueprint for a timber industry in Southeast Alaska has changed dramatically since the 1950s when the Forest Service offered timber sales to attract a pulp industry in the region. The Forest Service believed that the Tongass could supply up to 1.8 billion board feet of timber *yearly* in a biologically sustainable fashion. That timber was just a part of the then-estimated 95 billion board feet to lie in the 9.5 million acres of commercial forest lands in the Tongass.[20] The *Alaska National Interest Lands Conservation Act of 1980* (ANILCA) reduced that harvest target from federal lands to 450 million board feet (mmbf) a year, providing mandatory spending of $40 million a year for pre-commercial thinning and other work to allow that harvest level to be met while removing 5.7 million acres from the forest land base – land placed in conservation system units, protected habitat, and wilderness. ANILCA:

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[18] Southeast Alaska Native Land Entitlement Finalization Act (Sealaska Lands Bill), Pub. L. No. 113-291 § 3002.

[19] Tongass Advisory Committee (TAC), *Final Recommendations*, 2 (December 2015), available at http://www.merid.org/~/media/Files/Projects/tongass/December%202015%20Meeting/Tongass%20Advisory%20Committee%20Final%20Recommendations_Dec%202015.pdf.

[20] Sen. Frank Murkowski, *The Tongass, Fact versus* Fantasy, 4 (Chart on Timber Harvesting in Tongass Compared to Biological Capacity, U.S. Forest Service Data) (August 1996).

> "Represented a proper balance between the reservation of national conservation system units and those public lands necessary and appropriate for more intensive use and disposition and thus Congress believes that the need for future legislation designating new conservation system units (CSUs) ... has been obviated thereby."[21]

It took Congress just ten years to repeal the 1980 silviculture subsidy, to reduce the allowable timber harvest target to between 220 to 267 mmbf, and to add another 722,000 acres into protected status/CSUs. By the Forest Service's own estimates at the time, in 1990 the Tongass produced 6,113 direct jobs, contributing $516 million to the state's economy from the harvest of 471 mmbf of timber from federal lands.

The TLMP finally approved in 1999 to implement the *Tongass Timber Reform Act* (TTRA),[22] passed nine years earlier, anticipated a harvest or Allowable Sale Quantity (ASQ) of between 153 and 187 mmbf.[23] The Forest Service was required to "seek to meet" the demand for then existing timber markets. The mills supplying those markets all were equipped to process larger diameter, old-growth timber. Mills whose customer base was (and largely continues to be) tailored toward processing of that type of wood assumed its availability. In 1999, the harvest still reached 146 mmbf.

For a host of factors, some market driven, but others driven by environmental group litigation and the inability of the Forest Service to provide a consistent quantity of timber to satisfy markets and prevent customer switching, sale levels declined dramatically for more than a decade. In 2005 harvests fell to 50 mmbf, and over the next 10 years they have averaged just 33.3 mmbf, generally far less than the "market demand" for the timber. During that period, while the Forest Service offered (or attempted to offer) 57.8 mmbf a year, the Service only successfully sold 35.4 mmbf a year – litigation and Forest Service sale policies significantly reduced the amount of timber being utilized in the forest.[24]

As a result, a host of mills in Southeast Alaska have closed. This has resulted in the loss of more than 5,000 timber and timber-related jobs. Ketchikan lost a 500-employee pulp mill, two 100-employee sawmills and later an 100-employee veneer plant, Sitka lost a 500-employee pulp mill, Prince of Wales Island, lost a 25-employee sort yard and 700 logging and road building jobs, Wrangell lost a 100-employee sawmill, and Metlakatka lost an 100-employee hemlock mill and 100 jobs in road building and logging. Other parts of the region faced and are facing steep indirect job losses. The industry, which once accounted for nearly 80 percent of all manufacturing jobs in Alaska and produced a payroll of more than $300 million a year in 1991, today has been reduced to an industry that accounts for only about 600 total jobs and a total

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[21] Alaska National Interest Lands Conservation Act of 1980, PL. 96-487 § 101(d).

[22] Tongass Timber Reform Act, Pub. L. No. 101-626.

[23] I do understand that the Forest Service since 2012 no longer uses the term Allowable Sale Quantity to characterize timber sale offerings having moved to Projected Timber Sale Quantity (PTSQ). ASQ is used here simply because it was in usage at the time of ANILCA and TTRA's passage and reflects the expected timber offerings by Alaskans, dependent, of course, on the level of congressional funding provided to the Forest Service for planning/execution of timber sales.

[24] U.S. Forest Service, *Alaska Region Timber Volume History* (January 2015).

payroll in the region of approximately $27 million.[25] Despite these losses, the timber industry is important locally in the "Panhandle" of Southeast Alaska. For example, from 1990 to 2000, following passage of the Tongass Timber Reform Act and the eventual closure of the Alaska Pulp Co. mill in Sitka and the Ketchikan Pulp Co. mill in Ketchikan and sawmill in Wrangell, Southeast's total population declined by 7 percent.

The decline continued from 2000 to 2010 because of the marked slowdown in timber harvesting. From 2000 to 2010 total population in the region declined to 69,849 from 73,082, a further decline of 5 percent; 24 of the region's 34 communities are facing declines: from 2 percent in Hydaburg, now a shipping port for log exports, to 57 percent in Point Baker on northern Prince of Wales Island.[26] Almost exclusively linked to the downturn in timber employment, state elementary schools in six communities closed following a region-wide enrollment decline of 15 percent – the schools in Edna Bay, Elfin Cove, Meyers Creek (Chuck), and Whale Pass remain closed. Ketchikan (both City and Ketchikan Gateway Borough), for example, saw its population peak in 1995 at 14,800. While it bottomed out in 2004 at 13,200, it still is only at about 13,900 – 900 fewer residents in the area than at logging's peak. Ketchikan's average wage in 2013, the most recent year for data, was $42,767, considerably below its pre logging era collapse and well below the statewide average of $51,033.[27]

On Prince of Wales Island, the downturn in the timber industry caused far worse economic impacts. The Island's population, according to the U.S. Census Bureau, fell 20 percent from 1996 to 2007. The Island, once fueled by timber, is now dominated by government agency spending. Some 52 percent ($38 million) of the total census area wages in 2011 were funded by government agencies and natural resources provided just 6 percent of wages.[28]

According to Southeast Conference, the umbrella organization for all communities in Southeast, timber jobs and payrolls fell by 24 percent from 2006 to 2011. Timber, which accounted for 4,500 direct jobs in the region in the late 1990s, by 2011 accounted for just 422 jobs and wages were down to $16.8 million.[29]

Even though the seafood industry increased 4 percent from 2006 to 2011, generating $391 million in ex-vessel value for Southeast residents, and even though tourism fell 6 percent from 2006 to 2011, generating 6,000 part-time and some year-round employment with a payroll of

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[25] Caroline Schultz, *Alaska's Timber Industry Fallen on Hard Times*, ALASKA ECONOMIC TRENDS, Alaska Department of Labor and Workforce Development, 14 (October 2010), available at http://laborstats.alaska.gov/trends/oct10art2.pdf.

[26] Alaska Department of Commerce, Division of Economic Development, *Report to the Alaska Timber Jobs Task Force*, 3 (March 2012).

[27] Conor Bell, *Ketchikan's Fluid Economy: Alaska's Gateway City, From Mining and Timber to Fishing and Tourism*, Stories in the News/Sit News (August 16, 2014), available at http://www.sitnews.us/0814News/081614/081614_ketchikan_economy.html (citing the Alaska Department of Labor and Workforce Development, Research and Analysis Section).

[28] *Prince of Wales Area Redefines its Economy after the Timber Decline*, Stories in the News/Sit News, 2-3 (August 1, 2012), available at http://www.sitnews.us/0812News/080112/080112_POW.html.

[29] Southeast Conference, *Southeast Alaska by the Numbers*, 8 (2012), available at http://www.seconference.org/sites/default/files/Southeast%20Alaska%20by%20the%20numbers%20small%20for%20emailing%20and%20web.pdf (citing the McDowell Group and the U.S. Forest Service).

$164 million, and even though mineral development has grown in Southeast, to 650 jobs and a $60 million payroll by 2011 (largely as a result of the opening of the Kensington gold mine in Juneau and the reopening of the Greens Creek silver mine outside of Juneau), timber could still play a vital role in a balanced economy in Southeast Alaska. That would be the case if timber production was allowed to return just to the allowable sale quantity levels permitted by the 2008 TLMP.[30]

This history provides the foundation for the following comments on the Plan.

CRITERIA FOR PLAN ALTERNATIVES – The Plan Amendment process was fundamentally flawed because the Plan, rather than looking objectively at the outcome of all reasonable forest alternatives, appears to have been predetermined in order to support a prior decision to exclude consideration of a more robust timber harvest scenario.

The Plan Amendment process was fundamentally flawed because the Plan, rather than looking objectively at the outcome of all reasonable forest alternatives, was gerrymandered as a result of the 2013 Memorandum and the decision to exclude consideration of a more robust timber harvest scenario. The Forest Service admits that early in the Plan:

> In the past Forest Plan revisions and amendments, varying demand scenarios were used to develop alternatives, including scenarios that allowed for growth and expansion of the current industry. In this amendment, the purpose and need demands the transition to a predominately young-growth-based industry and the reduction of old-growth harvest. Therefore, examination of alternatives at levels above projected demand is not warranted because these would require expansion of old-growth harvest levels, at least during the next 10 to 20 years."[31]

Worse, the forest "demand level" used as the base for sale forecasts in the document is not a real assessment of the market "demand" for timber, as required by Sec. 101 of the *Tongass Timber Reforms Act of 1990*.[32] The five alternatives in the Proposed TLMP are assessed against the baseline "demand estimate" used by the Forest Service in crafting the Plan Amendment. The *Tongass National Forest Timber Demand, Projections for 2015 to 2030* (the Demand Estimate), crafted by economists from the Pacific Northwest Research Station,[33] estimates that only 40.9 mmbf was sought by markets in 2015 and that only 41.6 mmbf will be sought in 2016 – a demand level that rises to a range of between 51.9 and 76.4 mmbf by 2030 as young-growth production increases.[34] Nowhere in the Plan does it justify why the demand level that effectively controls the consideration of the five alternatives is more than 100 mmbf less than the Forest Service's published demand levels for 2014, of between 110 and 151 mmbf in a "Limited

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[30] *Id.* at 6-10.

[31] USDA Forest Service, *Tongass Land and Resource Management Plan: Draft Environmental Impact Statement – Plan Amendment*, 2-9.

[32] Tongass Timber Reforms Act of 1990, Pub. L. No. 101-626 § 101 (amendment to Pub. L. No. 96-487 § 705(a).

[33] Jean M. Daniels, Michael D. Paruszkiewicz, and Susan J. Alexander, *Tongass National Forest Timber Demand, Projections for 2015 to 2030* (December 2, 2015).

[34] USDA Forest Service, *Tongass Land and Resource Management Plan: Draft Environmental Impact Statement – Plan Amendment*, at 2-8 (Table 2-1).

Lumber" scenario and between 110 and 163 mmbf in an "Expanded Lumber" market scenario.[35] The 2015 demand estimates varied from between 58 to 113.2 to 204 mmbf on a slightly revised demand report.[36]

A review of the Demand Estimate, however, does shed light on the marked differences. "Efforts to end harvesting of old-growth timber on the Tongass National Forest have spurred multiple initiatives focused on transitioning to a young-growth timber base. The young-growth transition is expected to affect timber supply for the remaining Southeast Alaska forest products industry," write the authors.[37] While noting that timber sale demand from Alaska may be impacted in the future by changes in domestic and export forest product markets, by foreign currency fluctuations, and by changes in the federal timber base because of lands legislation or congressional action, the report noted that this Demand Estimate was influenced by the Secretary's Memorandum. "Efforts were set into motion by evolving USDA policy limiting old-growth harvesting and encouraging the harvest of younger second-growth forest stands."[38] "Although this is an analysis of timber demand, it is important to remember that the interaction between demand and supply is what ultimately determines trends in markets," continues the demand report.[39] Thus the Demand Estimate, which is the basis for the Forest Service not seeking to offer more old-growth timber to meet "market demand" and for seeking an amendment to the 2008 TLMP, is being driven in significant ways not by markets, but by the limitation of timber supply available to markets – a process, in turn, that is solely being driven by the Secretary's policy directive mandating a rapid transition to a young-growth industry.

Alaska mill operators, even with the downturn in American timber export markets in 2015 spurred by the strengthening of the U.S. dollar, have repeatedly indicated that market demand for timber would have allowed them to harvest and process far more timber, if a larger multi-year, dependable supply of federal timber had been made available. The Viking Lumber Mill at Klawock, for example, has "repeatedly told the Forest Service that they would like to purchase more timber sales because their customers have additional capacity and Viking wants to more fully utilize (their) mill," according to comments by the Alaska Forest Association.[40] More timber availability would have improved the mill's efficiency, which the Forest Service's Demand Estimate seemingly places at about 18.75 percent in 2013.[41]

The Forest Service is arguing that it does not need to offer more timber because "demand" for timber was down because of lower sale levels. But without more economically appraised timber being put up for sale, the industry has nothing with which to attract market buyers. Except for 2014's Big Thorne timber sale, the Forest Service was only planning to offer sales of another 60 mmbf of old-growth saw and utility logs at Mitkof and Three Sisters Island and a 4.2 mmbf

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[35] U.S. Department of Agriculture, U.S. Forest Service Alaska Region Briefing Paper, 1 ("Predicting Likely Timber Purchases and Offer Levels on the Tongass National Forest. Fiscal Year 2014") (February 2014), available at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5447816.pdf.

[36] *Id.* at 9 (Table 5 "Projected Tongass National Forest Timber Harvest (Model Item K)").

[37] Daniels, *Tongass National Forest Timber Demand*, at 5.

[38] *Id.* at 3.

[39] *Id.* at 4.

[40] Alaska Forest Association, *Comments on U.S. Forest Service Tongass National Forest Timber Demand*, at 6.

[41] Daniels, *Tongass National Forest Timber Demand*, at 8.

young-growth sale at Dargon Point in 2015 – none completed. Proposed sales in 2016, according to preliminary Forest Service sale documents, at Saddle Lakes, Kuiu Island, and from Koscuisko and Wrangell Islands, as of this writing, are just 51 mmbf, which is not enough to support higher timber production, artificially limiting the timber demand levels.

This makes the Plan Amendment process based on an obviously circular argument: the only alternative that can be accepted is one that does not exceed market demand estimates, while those estimates are clearly being limited so that they don't exceed the reduction in old-growth harvest levels being driven by the Secretary's policy decision to accelerate a transition to young-growth harvesting.

The Forest Service should be adopting a more rational "no-action" amendment, at least as it relates to the timber program. That would allow harvests at the levels anticipated by the 2008 TLMP of up to 167 mmbf a year, depending upon congressional appropriation, while not preventing the Forest Service from offering more young-growth sales to help begin a transition to a Y-G industry.

ENVIRONMENTAL IMPACTS – Concerns about the effects of a larger harvest on the environment, commercial fishing, and tourism are unsupported by the record.

The Forest Service leadership obviously is opposed to such a large harvest. Consider, however, what a larger harvest would mean to the forest, the environment, and its resources. Based on the 2008 TLMP, admittedly crafted on the 1982 planning rules and not the revised 2012 rules, logging would limit impacts in the land under Forest Service control to just another 655,000 acres of the remaining 5.6 million acres of commercially productive forest. That would mean that no more than 12 percent of the commercially productive forest will ever be affected and less than 4 percent of the total forest.

Already, 4.9 million acres of the productive forest – 88 percent – are in protected status and unavailable for logging or construction activity. Of the total Tongass, besides the 6.5 million acres in wilderness, parks, monuments and LUD II land status, another 9.5 million acres are currently classified by the Forest Service as Inventoried Roadless Areas (IRAs) – which prevents road construction and any activities that will dramatically reduce biological protections for wildlife. Even if the Forest Service's Alternative One from its Plan document would be selected, an alternative modified by the 2012 planning rules, just 40,140 acres of old-growth would be harvested over the next 25 years (generating up to 118.7 mmbf of harvest annually), and only 62,413 acres of old-growth would be harvested after 100 years. That means after 100 years only 1.2 percent of the productive old growth would be harvested in the Tongass, i.e., 90 percent of the original amount of productive old growth will remain, and just 1 percent less than under the other four alternatives being considered by the Plan Amendment.[42]

That also means 82 percent of all high volume, POG trees will remain in the Tongass untouched after 100 years, just one percent less than the other four alternatives. Some 80 percent of POG will remain in 100 years compared to the 82 percent that now exists in the forest, just one percent

[42] USDA Forest Service, *Tongass Land and Resource Management Plan: Draft Environmental Impact Statement – Plan Amendment*, at 2-43 (Table 2-18).

less than in the other four alternatives. According to the data developed in the Forest Service's *Tongass Land and Resource Management Plan: Draft Environmental Impact Statement – Plan Amendment* (the DEIS), deer habitat will be 87 percent of the levels of 1954 (before commercial timber harvesting began), just 1 percent less than under the other four alternatives, and just 2 percent less than today's level.[43]

The leading concern with timber harvesting is traditionally the effect of logging on commercial fishing, specifically salmon production. But the record of fisheries and timber is quite clear – it is fully possible to permit logging by means of modern-era logging practices without negative environmental impacts on fisheries. Exempting minor spruce harvesting during World War II, modern commercial logging began in the Tongass in 1954. In 1954 Alaska statewide produced 44.29 million salmon. While harvests declined to 25.12 million salmon at the time of Statehood in 1959, because the federal government allowed the use of fish traps, commercial salmon harvests rebounded to set a then record of 189.51 million in 1991 – the peak year for timber production from Southeast Alaska – proving that the fish harvests were not harmed in spite of timber harvesting. Despite the timber harvests, pink salmon production (Southeast being the leading source for pink salmon in the state) hit a then record of 128.33 million pink salmon in 1991. While pink returns biologically usually are higher in alternating years, pink returns to the state surpassed the 90 million mark 14 times from 1989 to 2011 – when logging on federal, state and Native corporations lands were at their peak – while pink production had only passed the 90 million mark once from 1878 to 1989. Clearly, that record of increasing salmon production is partially the result of state management, partially the result of the state's regional aquaculture program that began in the mid-1970s, and partially the result of moderating weather and stream conditions improving fry survival. But it also undercuts the argument that timber production in Southeast Alaska harms salmon production.[44] Timber harvest practices have improved in Alaska, especially since the late 1980s, further reducing the impacts of timber operations on fisheries.

It is equally unpersuasive to argue that timber production has harmed tourism in Southeast Alaska. In 1985, 497,300 visitors came to Alaska. By 1999, when timber harvesting was at 146 mmbf (one of the last years above 140 mmbf) tourism in Alaska reached 1.199 million visitors.[45] The impacts of the logging of 435,000 acres of the region certainly have not prevented tourists from visiting. According to the most recent extensive study of tourism, 1,064,000 visitors came to Southeast in 2011-12 out of a total visitor volume to the state that year of 1.82 million. Visitors spent $1.003 billion in Southeast in 2011-12. This is hardly an indication that timber development has destroyed Alaska's environment and reduced its attractiveness to tourists.[46]

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[43] *Id.* at 2-44, (Table 2-18 continued).

[44] Alaska Department of Fish and Game, *Alaska Salmon Catches 1878 to 2011* (2012).

[45] McDowell Group Inc., *Economic Impact of Alaska's Visitor's Industry 2011-2012*, 3 (February 2013), available at https://www.commerce.alaska.gov/web/portals/6/pub/Visitor_Industry_Impacts_2_13.pdf.

[46] *Id.*

ECONOMIC IMPACTS – An immediate transition to a young-growth forest management program is unreasonable and economically unjustified.

There is no basis for the Forest Service to limit old-growth logging to the levels that would be enshrined in the TLMP by approval of the proposed Plan Amendment, especially when it is not clear that an industry can afford to transition to Y-G timber.

Except for Federal Forest Service timber lands, there are few other lands available for timber production in the region. The total state forest lands in Southeast covers about 50,000 acres.[47] That equates to an allowable sale quantity of only about 11 mmbf a year over the next 100-year rotation. Information provided by the Alaska Division of Forestry shows that while it can consider about 70 mmbf in sales from Prince of Wales Island and perhaps 50 mmbf total in other sales (the Vallenar Bay sale at12 mmbf and the Edna Bay sale on Koscuisko Island at 24.5 mmbf are among the largest) after that state additions to the timber base will be relatively small.

Looking at Native owned tracts, all provided as a result of the Alaska Native Claims Settlement Act of 1971, Sealaska Native Regional Corporation has about 292,000 acres of timber lands out of its 365,000 total acres that it has and will receive under the act. While village corporations may have more second-growth acres, there is a real question whether many of those acres will be of sufficient size to make Y-G harvesting economic in future decades. One of the key problems with the DEIS is that it assumes, based on the Demand Estimate, that about 61 mmbf a year are currently available to support a Y-G transition – a figure that will rise to about 80 mmbf over the 15 year transition.[48] However, the fact that Sealaska is estimating that its sustainable harvest over the next 25 years is only about 45 mmbf annually casts doubt on the accuracy of that entire part of the supply forecast – the part upon which the DEIS transition policy is based.[49]

In the Lower 48 the average Y-G mill costs about $100 million to build and equip – more than the total capitalization of Alaska's existing timber industry. The Forest Service's own Demand Estimate questions whether a young-growth transition is feasible. "Whether Alaskan products will remain competitive during the young-growth transition will depend on a variety of factors," the market Demand Estimate concludes. It suggests that for a transition to be successful, given the limited volumes of young-growth available based on current land uses, a biomass and a wood pellet industry will need to be developed to better utilize wood waste from young-growth product production. It notes for that to happen wood pellets will need to replace 30 percent of the heating oil currently used in Southeast Alaska for home heating. "Producers, however, may find it difficult to compete with pellet producers in British Columbia in international markets. In addition, transportation challenges make it difficult for Southeast Alaska producers to ship material to other regions within Alaska itself. There is tremendous interest in developing markets for value-added niche products. Whether demand for these products would be sufficient to sustain a timber industry in southeast Alaska will likely be the subject of debate for many years to come," concludes the Demand Estimate.[50]

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[47] State of Alaska Division of Economic, *Development Report to the Alaska Timber Jobs Task Force*, 2 (March 2012).

[48] Daniels, *Tongass National Forest Timber Demand*, at Table 22.

[49] *See* comments by Sealaska and by the Alaska Forest Association for additional details.

[50] Daniels, *Tongass National Forest Timber Demand*, at 32.

That is hardly a firm foundation upon which to base a transition to a young-growth industry, or on which to base adoption of the Proposed TLMP to start implementation of that transition.

If the Forest Service is intent upon proceeding with one of the published alternatives, then Alternative 5, the preferred alternative, is best to ensure continuation of some timber industry in Southeast Alaska. It allows more old-growth to be harvested than any of the three reduced-harvest alternatives, and allows the transition to stretch over a longer period of time. It also comes closer to meeting the recommendations of the TAC than the other three reduced timber alternatives (Alternatives 2-3-4). But the alternative is still defective because it does not include any of the suggestions the State of Alaska offered in the state's harvest alternative, does not consider the impacts of the Alaska Mental Health Trust land exchange that is currently being considered by the Forest Service in the region, and does not follow the more reasonable 1982 planning rule procedures.

ROADLESS RULE REVISION – Harvesting should be permitted from existing roads that have already been built in the Tongass.

There are good reasons to include one part of Alternative 2 in a final new TLMP. Alternative 2 proposes to allow timber harvesting in areas where roads were built prior to the adoption of the federal Inventoried Roadless Area (IRA) Rule in 2001. There are nearly 33,000 acres of timber in the Tongass that are currently off limits to timber harvesting, but accessible by established roads. This is largely because the final IRA regulations were not updated to reflect as-built roads in the Tongass between when roadless designations were first proposed as part of the RARE II process in 1978 and when the IRA regulations were issued in 2001. The 2008 TLMP certainly does not consider the additional roads built in the forest between 2003 and 2009, when the rule was not in effect in the Tongass because of a court accepted consent decree, but then was reinstated early in the Obama Administration – a decision still being litigated. Harvesting should be permitted from existing roads that have already been built in the Tongass. It should not be prohibited simply because of planning inertia that was in effect prior to adoption of the IRA rule by the Clinton Administration.

TIMING ISSUES OF PLAN AMENDMENT – The Forest Service should ensure that a transition is economically feasible and likely to succeed *before* amending the 2008 Plan and "locking in" reduced old-growth timber harvest offerings.

As noted above, it seems clear that the final new TLMP will be crafted and reviewed before there is data that confirms the volume of young-growth timber currently available for harvest in the Tongass, and long before an economic study is finished that confirms that it will be financially viable for a Y-G industry to develop (and find profitable markets for its products) based on that level of wood volume.

In its final recommendations, the TAC acknowledged that there are still considerable uncertainties in the amount, volume, and timing of the availability of Y-G to support a transition. Among the panel's overarching principles is the statement that "due to uncertainties in young growth inventory data and often significant differences in on the ground operational outcomes,

independent monitoring is essential to achieve the dual objective of reducing old-growth sooner and providing for a viable timber industry."[51]

During its review of forest policy, the TAC noted that of the 16.7 million acres of the Tongass under Forest Service control, 13.3 million acres already are under wilderness (5.9 million acres) and Natural Setting classifications (7.4 million acres). That leaves just 3.4 million acres for any development.[52] The panel found that of the 435,000 acres of the Tongass that have already been harvested, most harvested since 1954, only 273,000 acres are areas currently considered as "suitable" for harvest – outside of beach fringe and stream buffers – and only 186,000 acres currently are in Forest Service areas open for Y-G harvesting. More than 120,000 acres of Y-G is currently classified as non-suitable for second-growth harvest.[53]

The Forest Service, acting on the TAC recommendations, proposed in July 2015 to fund up to $4 million of studies to update the inventory of young-growth by location and to develop better data on the growth rates of young-growth trees. While a privately funded study was in process in late summer and early fall of 2015, the separate Forest Service funded study of inventory, led by the Pacific Northwest Research Station with assistance from the State of Alaska's Division of Forestry personnel, was delayed from the start. Work presumably continues to progress on the methodology to guarantee that it will provide credible data from more age-classes of Y-G timber in more locations forest-wide and on all slopes, not just on southern facing slopes (southern slope trees due to ground warming in northern climates usually produce the biggest and fastest growing trees). Consequently, that study is unlikely to be started until spring 2016 and unlikely to be completed prior to the finalization of the final new TLMP planned for December 2016.

Even if the study will be completed in time, the study, as currently envisioned, will not produce the quality of data needed to accurately forecast future Y-G timber availability forest-wide. Again, the inventory study should sample young-growth from all land areas and all age classes. Harvests in the Tongass before 1976 tended to be at low elevations, below 500 feet, where harvesting costs were the lowest, but also where trees grow the fastest from warmer soil temperatures. Harvesting – and thus future tree growth after 1976 where about two-thirds of the future Y-G trees will come from – will produce markedly different growth rates and thus different harvest volumes. Appendix B-2 of the DEIS seems to imply that while new site class/site index data was estimated and fed into the computer models used to estimate wood availability, there were not any actual field surveys at the time of the DEIS to prove the accuracy of the site index information upon which the new land Plan Amendment is based. Until the site index data is confirmed as accurate across all age classes and all terrains and elevations in Alaska, not just the Pacific Northwest, it would appear to be impossible for either the Forest Service or private mill operators to have much faith in the accuracy of the DEIS. All of the assumptions on the economic feasibility of a transition flow from this basic data. How can, for example, logging costs for Y-G timber be accurately forecast without true faith in the volume estimates? How can the computer models be upgraded to depict Alaska Y-G timber output if the volumes and grades for that timber are in so much doubt, affecting saw and utility log forecasts?

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[51] TAC, *Final Recommendations*, 4.

[52] *Id.* at 1 (a slightly different number than the Forest Service projections).

[53] *Id.* at 8-10.

The Alaska Forest Association and individual timber operators in the region will likely express similar concerns with greater precision in their comments.

Equally important, the TAC urged that funding take place for studies into the economics of product formation from Y-G timber. "There is limited information available on growing, managing, harvesting, processing, manufacturing, and marketing of young-growth timber within Southeast Alaska. Additional research regarding young-growth silviculture and operability is necessary to support a viable transition."[54] The committee noted that for a Y-G industry to succeed businesses will have "to adapt their business models and develop new products and markets." It recommended that the Forest Service "provide assistance to communities and businesses, conduct market analysis and products demand analysis" to aid a transition.[55] An economic analysis should proceed and be funded and finished *before* a plan amendment to the 2008 Plan is proposed, much less adopted.

U.S. Department of Agriculture (USDA) officials have voiced support for providing additional funding to cover an economic study of products that may be produced in Alaska from Y-G timber, to estimate costs of production, transportation and sale. The environmental community has expressed support for such studies. Such studies need to be conducted. My concern is that the Secretary did not propose any money for such studies in the Administration's FY 17 budget released February 9, 2016, nor did the budget propose any additional funding for the inventory studies cited above. Without the Secretary and Forest Service committing significant funds to advance their transition, the transition will falter.

I suspect that even more funding will be required for economic and marketing studies before private financing will be available to support a Y-G transition. The financial analysis on Page 3-481 of the DEIS, for example, indicates that all of the plan alternatives, including the preferred Alternative 5, have a positive net present value. And Table 3.22-16 indicates that Alternative 5 will result in a $112.9 million net present value. But without any information on the cost of Y-G harvest, much less better estimates of the reduction in the value of POG when sale areas decrease and production costs rise, how can estimates that predict Forest Service costs will be about $105 per thousand board feet and the typical purchaser profit will be about $80 per thousand board feet possibly be accepted as potentially accurate? Until data on the volume of Y-G and data on the potential products that will be manufactured from Y-G, as well as their costs and profits, are generated, it is impossible to believe that forecast models, based on the Lower 48's experience, can possibly govern either Forest Service policy or private sector investment decisions. It is one thing to base policy on "informed estimates" when those estimates have a reasonable, proven basis in fact, but it is a totally different case to base public policy on forecasts that have such a tenuous relationship to proven facts in Alaska – given its different marketing costs, labor costs, transportation costs, operating costs, and likely volumes of future wood availability.

While it is fully appropriate for the Forest Service to continue to study and develop actual data that may prove that a transition to greater Y-G usage can happen sooner than the industry's expectation of 30 years, it is inappropriate for the Plan Amendment to be proposed, much less

[54] *Id.* at 24 (Research Investments).

[55] *Id.* at 25.

finalized, until that work is undertaken – something that is unlikely to happen prior to 2017 on a forest-wide basis at the current level of funding seemingly being proposed by the Forest Service.

TONGASS ADVISORY COMMITTEE RECOMMENDATIONS – The Forest Service should take closer account of the TAC's detailed recommendations.

While I will leave it to the TAC to file their own comments on the Proposed TLMP, it is noteworthy that the Forest Service has declined to follow a number of the TAC recommendations.

To encourage a transition to Y-G sooner than market conditions might allow, the TAC proposed a system of "co-intent" where Y-G acreage in "unsuitable" areas could be harvested within the first 15 years of a transition to provide greater volumes quickly to permit an economic transition to begin. But the Forest Service's Alternative 5 includes restrictions of harvesting in such areas that may make it far harder for such Y-G harvesting to take place economically.

More important, the TAC recommended that if any suitable young-growth acres are removed from the timber base as a result of future review processes, an equal number of acres should be added to the Y-G base. This effectively prevents the continual chipping away of a commercial timber base as has been the case under recent Forest Service TLMP revisions. There is nothing in Alternative 5 that seems to carry out that requirement – a key basis for the panel reaching consensus on its recommendations. There is also little in the Plan Amendment alternatives that will implement the TAC's detailed recommendations on additional federal aid, new policies for planning and overseeing sales, guarantees that timber sales will be conducted to provide a reliable supply of timber for mill amortization, or on its requests for new oversight panels governing and reviewing forest plan implementation and enforcement.

RENEWABLE ENERGY OVERLAY – The plan revisions should give greater assurance of speedy approval for roads or transmission facilities through roadless areas to developers of proposed renewable energy projects.

As part of its plan update, the Forest Service agreed to consider changes in regulations governing the construction of roads and electrical transmission lines to facilitate the economics of construction of renewable energy projects in or through the 9.5-million acres of Inventoried Roadless Areas (IRAs) in the Tongass. In my comments of June 26, 2014 on the harvest plan, I encouraged the Forest Service to modify the 2008 Plan to make it clearer and easier for roads and utility systems to be built to facilitate less expensive construction of renewable energy projects, and also to aid economic development of mineral deposits in the forest.

I welcome the decision of the Forest Service to include language in the plan update to make its intent known that it wants to facilitate construction of roads and electrical transmission lines for renewable energy developments. Unfortunately, it's far from clear that the actual plan revision will give any greater assurance of speedy approval for roads or transmission facilities through roadless areas to developers of proposed renewable energy projects.

Because the Forest Service prepared the post-World War II study that noted nearly 200 sites in Southeast Alaska that could potentially be tapped for hydroelectric power generation, there are innumerable sites that could permit lower-cost hydroelectric generation. Such cost savings are considerable in light of the roughly 60-cents per kilowatt hour cost of diesel-fueled generation in the region (a cost that admittedly has fallen recently due to falling world oil prices). Theoretically, transportation and utility access was guaranteed through most of the Tongass National Forest by Title 11 of ANILCA, which set up a process guaranteeing access through conservation system units after the agency ruled that IRAs are covered under that definition. A consent decree several years ago did permit about a dozen projects to proceed in roadless areas. But that ruling leaves out many dozens more. While the existing 2008 Plan does not preclude construction of roads and utilities in roadless areas, it does contain regulations that complicate approvals for roads and transmission facilities in some Land Unit Designation (LUD) areas. Although the existing alternatives propose to provide more "flexibility" on a "case-by-case" basis for roads and utilities, the language does not provide sufficient certainty of approval to encourage developers to advance costly reconnaissance studies of potential projects that could be impacted by roadless rule regulations. I strongly encourage the Forest Service to look again at how it is proposing to handle future requests for renewable energy developments in and impacted by roadless areas to prevent needless costs and development uncertainties.

MINERAL DEVELOPMENT ACCESS – The Forest Service should allow roads through roadless areas to guarantee more affordable access to mineral developments.

Concerning mineral development, the draft alternatives do nothing to allow development of roads or power transmission lines through IRAs to aid mineral developments in the region. The 2001 Roadless Rule allows for "reasonable access" to locatable minerals covered by the Mineral Leasing Act of 1920.[56] But agencies have defined "reasonable" access to not be determined by the economics of access.

Thus, if a mine site can be accessed by water, the Forest Service is unlikely to approve roads that likely would make access less expensive for both the mineral developers and for workers heading to the project, even though the January 2001 regulations permit roads to be built across inventoried roadless areas if needed "in conjunction with the continuation, extension or renewal of a mineral lease on lands that are under lease by the Secretary of the Interior."[57] The Forest Service, for example, in 2013 opposed legislative efforts to speed a permit for a road through an IRA to reach either the Niblack or Bokan Mountain mineral and rare earth element deposits on southeastern Prince of Wales Island. While access to the mines can come by water, workers living on the island will effectively have to reach Ketchikan in order to be transported back to the mines for work – a more dangerous and time consuming process than if they could simply drive to work by the road network on the Island. It would make great sense for the USDA, which two years ago classified Southeast Alaska as a high unemployment area, authorizing it to receive aid from its Operation Strikeforce initiative, to allow roads through roadless areas to provide more reasonably priced access for workers to mineral developments. Any plan update should be modified to guarantee more affordable access to mineral developments.

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[56] 36 C.F.R. Part 228.

[57] 36 C.F.R Ch. II § 294.12(b)(7).

GENERAL ADDITIONAL POINTS:

The Proposed TLMP and the Demand Estimate have a variety of other issues. There are serious weaknesses in both the Demand Estimate and in the DEIS. For example, in no particular order:

- The demand analysis does not make any estimates as to the cost of accessing, transporting, and harvesting of Y-G timber, undercutting the credibility of its cost estimates.
- The demand analysis contains no Alaska-specific estimates of the cost of producing products from Y-G timber, which undercuts the credibility of its estimates for the demand for Y-G in the first 10 years, and in years through 2030.
- The DEIS on Page 3-223 argues that an Alexander Archipelago wolf threatened or endangered listing decision under the Endangered Species Act would impact timber harvesting and seemingly require greater use of Y-G. Since the listing did not take place on January 6, 2016 and the USF&WS ruled that the Alexander Archipelago is not a unique subspecies of gray wolf, that assumption affecting the Plan is invalid.
- The demand report argued that biomass from Y-G timber could be economic because of the high price of diesel fuel for home heating. Given current world prices for crude oil of around $28 a barrel, the price for diesel fuel is falling rapidly which undercuts the methodology of the demand study. As of January 20, 2016, diesel prices nationwide on average were $2.13 a gallon, compared to $2.89 one year earlier – a fall of 35%.[58]

CONCLUSION:

Since the start of commercial logging in an area slightly larger than West Virginia, only about 435,000 acres of the nearly 10 million acres of total forested lands have been disturbed by humans, or just eight percent of the total productive forest. By allowing an alternative that might involve harvesting of just 17,000 more acres of old-growth timber over the next quarter century than the other four plan alternatives, the Forest Service could well restore hundreds of direct and indirect jobs in the region, without noticeable harm to the region's commercial fisheries, wildlife habitat, Native subsistence activities or the environment. By simply following the existing 2008 Plan, it could add even more jobs and payroll in an economically distressed region, without harm to the environment or wildlife or fisheries. The agency should wait to decide whether and what kind of TLMP plan update is required until there is firm data to support the Administration's policy decision to accelerate a transition to a young-growth forest management program in the region. A delay in this plan revision is the only action available to the Forest Service that is justified by the record.

Sincerely,

Lisa Murkowski
United States Senator

[58] AAA *Daily Fuel Gauge Report* (January 20, 2016), available at http://www.fuelgaugereport.com/.

STATE CAPITOL
P.O. Box 110001
Juneau, AK 99811-0001
907-465-3500
fax: 907-465-3532

550 West Seventh Avenue, Suite 1700
Anchorage, AK 99501
907-269-7450
fax 907-269-7461
www.Gov.Alaska.Gov
Governor@Alaska.Gov

Governor Bill Walker
STATE OF ALASKA

February 22, 2016

Mr. Earl Stewart
Forest Supervisor
Tongass National Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, AK 99901

Re: Tongass Land & Resource Management Plan Amendment and DEIS

Dear Mr. Stewart:

The State of Alaska (State) has reviewed the Draft Environmental Impact Statement (DEIS) for the U.S. Forest Service's (USFS) proposed Land and Resource Management Plan (Proposed Plan) for the Tongass National Forest and is pleased to provide its comments.

I appreciate the primary intent of the plan amendment to accelerate the transition from an old-growth to a predominantly young-growth forest management program in the National Forest, and to do so in a way that preserves and sustains a viable timber industry that provides jobs and opportunities for residents and communities in southeast Alaska. Through the Division of Forestry, the State actively participated in the Tongass Advisory Committee (TAC) that achieved consensus on a suite of recommendations to the USFS on its young-growth transition strategy. A key objective for the State is the triple bottom line, where social, economic, and environmental interests are balanced to produce an outcome with broad support. We must continue to work together to ensure that the Tongass National Forest provides maximum benefits to the communities of Southeast Alaska and all users of the forest.

I would also like to acknowledge the great work that has been done by the TAC. Rarely have I ever seen an effort like this, where stakeholders with such varied interests have come together to reach a consensus on a very complex resource management issue. I greatly appreciate the work of the TAC, and I hope that this committee, or one similar to it, will continue to help guide the USFS and the State as we continue to work toward a strong, vibrant economy for the residents of Southeast Alaska.

I am pleased that many key recommendations from the TAC were incorporated into Alternative 5 of the DEIS.

However, I am generally concerned about the underlying science and analysis that 1) supports the feasibility of young-growth forest management, and 2) demonstrates the effectiveness of such a strategy. The Forest Plan needs to include scientific information and sound analysis regarding both the silvicultural treatments necessary for timber production and a sustainable industry, and a concurrent analysis of how these treatments affect key wildlife species and their habitat. The plan must demonstrate, with accompanying science-based appendices, that young-growth management

can sustain timber outputs and useable and sustainable wildlife populations. This is particularly important in highly-modified landscapes.

While this is an amendment and not a full forest plan revision, the transition to predominantly young-growth harvest and management will be a ground-breaking event on the Tongass. Science is key to determining what is, or is not, feasible. For such a significant resource management policy change, the science and analysis must be rigorous. State resource managers believe more work is required in this area.

I would also like to highlight a significant concern that none of the alternatives will meet the requirement of the Tongass Timber Reform Act. The State encourages USFS to assess the legal consistency of the Forest Plan with the Act. The Act's clear directive to maintain a viable forest products industry supported by Tongass timber must not be lost in the evolution of Tongass National Forest policy. To do so only continues the crippling legacy of litigation and controversy that unfortunately is a historic legacy of Tongass forest management.

The State departments of Natural Resources, Fish and Game, Transportation and Public Facilities, and Environmental Conservation have carefully reviewed the Proposed Plan and DEIS. Their attached consolidated comments include more technical detail regarding the concerns listed above, as well as comments and suggested revisions on topics including timber demand calculations, transportation corridors, subsistence, fish and wildlife habitat, water quality, and consideration of wilderness and wild and scenic rivers. It must also be emphasized that mineral development and alternative energy values are of significant consideration.

Thank you for the opportunity to comment on the DEIS and draft Proposed Plan. Please contact the State of Alaska agency staff identified in the attached consolidated comment letter if you have any questions or you would like to discuss our comments in greater detail.

Sincerely,

Bill Walker

Bill Walker
Governor

Enclosure

cc: The Honorable Lisa Murkowski, United State Senate
The Honorable Dan Sullivan, United States Senate
The Honorable Don Young, United States House of Representatives
The Honorable Sam Cotten, Commissioner, Alaska Department of Fish and Game
The Honorable Larry Hartig, Commissioner, Alaska Department of Environmental Conservation
The Honorable Marc Luiken, Commissioner, Alaska Department of Transportation and Public Facilities
The Honorable Mark Myers, Commissioner, Alaska Department of Natural Resources

Tongass Land and Resource Management Plan Amendment
Draft Environmental Impact Statement (DEIS)
State of Alaska – Agency Comments
February 22, 2016

The State of Alaska (State) appreciates the opportunity to provide its comments on the Proposed Amended Land and Resource Management Plan (Proposed Plan) and Draft Environmental Impact Statement (DEIS) for the Tongass National Forest.

The State has participated in the development of the Proposed Plan since the U.S. Forest Service (USFS) issued a Notice of Intent (NOI) to prepare an environmental impact statement (Federal Register, Vol. 79, No. 101, May 27, 2014). The State submitted comments during the 30-day public scoping period and now requests your consideration of the following comments on the Proposed Plan and DEIS. These comments were prepared by the departments of Natural Resources (ADNR), Fish and Game (ADF&G), Transportation & Public Facilities (ADOT&PF), and Environmental Conservation (ADEC). They are presented in order of general priority.

FORESTRY[1]

The State, through ADNR's Division of Forestry, was an active participant in the Tongass Advisory Committee (TAC). The TAC was a formally recognized Federal Advisory Committee Act (FACA) process that achieved consensus on a suite of recommendations to the USFS on the Young Growth transition strategy. Many of the key recommendations from the TAC are incorporated into Alternative 5 of the DEIS, however there were many important recommendations concerning the transition that were not appropriate to include in the DEIS and Proposed Plan. These recommendations were focused on the forest plan implementation process and cultural change within the USFS that will be necessary to successfully navigate the agency, forest industry, communities and residents of the region through the transition.

The TAC charter was narrow and focused its effort primarily on the Young Growth transition and the timber management aspects of this challenge. There are other important economic sectors and interests at play in the Tongass National Forest and these interrelated interests should be addressed as the transition unfolds. Balancing these interests is no easy task but the TAC has taken the first steps in laying the foundation for this effort. The next steps of implementation and adaptation will be critical to the outcome of the transition. While the State fully supports the TAC process and recommendations, we have serious concerns with the Proposed Plan and DEIS.

[1] The State of Alaska point of contact for forestry-related comments on the Proposed Plan and DEIS is Jim Schwarber with DNR's Division of Forestry. He can be reached at james.schwarber@alaska.gov or 907-451-2704.

By providing the following comments, the State retains its right to file an objection after the public comment period closes on February 22 or consider other action.

Any national forest plan developed must meet all applicable laws including Section 101 of the Tongass Timber Reform Act (TTRA) of 1990 (Public Law 101-626) that states in part, "the Secretary shall to the extent consistent with providing for the multiple use and sustained yield of all renewable forest resources, seek to provide a supply of timber from the Tongass National Forest which (1) meets the annual market demand for timber from such forest and (2) meets the market demand from such forest for each planning cycle."

Currently the "existing industry" is an old-growth-dependent industry and the majority of the industry believes that old-growth harvest must continue until there is a sufficient quantity of young growth to supply the industry (greater than 100 MMBF); in addition for mills the young growth must reach sufficient size to produce clear cuttings for niche markets (150+ years of age) (See the attached Working Forest Group (TWFG) report, *Strategies to Maintain a Viable Timber Industry in Southeast Alaska, 2015*).

The annual market demand (seek to meet) in the past has been calculated by the Morse Methodology. The last information on the Region 10 website is for FY2014; for that year, the estimated volume the USFS should offer to meet the FY2014 sell objectives was 142 MMBF (line Q under the expanded lumber scenario). The annual projected timber sale quantity (PTSQ) under the amended Forest Plan should equal the annual market demand number. No alternative in the DEIS provides sufficient volume to meet this annual demand number. The proposed PTSQ in the DEIS, 46 MMBF, does not meet the requirements of TTRA sec. 101 to seek to meet the annual timber demand from the forest.

The Proposed Plan also does not meet the statutory requirements of TTRA because no alternative provides sufficient quantities of old growth during the planning cycle (life of the Plan, 15 years) to meet the demands of the existing industry which is old-growth dependent. Thus, regardless of which alternative is selected, the Proposed Plan will violate both prongs of the requirement of TTRA sec. 101 to "seek to meet" timber demand. This will be a fatal legal flaw in the amended plan. The language requiring the USFS to "seek to meet" timber demand is more than a mere suggestion from Congress that the Forest Service consider the timber industry in its planning process.

The TTRA includes caveats that recognize the USFS may not always actually meet the market demand for timber due to circumstances beyond its control, such as litigation that prevents a planned sale from actually being offered and sold. However, the intentional creation of a Forest Plan that on its face actually prevents the USFS from offering sufficient timber to meet demand cannot possibly be construed by the public or the federal courts as "seeking to meet market

demand." Based on the above, none of the action alternatives meet the Purpose and Need to preserve a "viable timber industry."

We find it problematic that the DEIS utilizes, as a foundational source, an unpublished draft report (Daniels, et al; in press) that is referenced 52 times. A final Timber Demand Study would be more appropriate considering its importance to informing the DEIS.

- Since the Tongass Timber Reform Act, sec. 101 requires the Forest Service to "seek to meet" timber demand, the use of an unpublished draft of timber demand projections is unacceptable in the DEIS. In addition, the Proposed Plan itself makes no direct mention of the Daniels et al. study.

- Daniel's draft Demand Study is flawed in part because of its incorrect assumptions of volume available from State and private lands, and by assuming this volume will be offered on an annual basis. Timber resources managed by the University of Alaska Lands Office and the Alaska Mental Health Trust will not contribute as much timber harvest in the near future as they have in the recent past. These two entities follow a different harvest strategy than the Alaska Division of Forestry does on the state lands it manages in Southeast Alaska.

- An unrealistic assessment of market demand may be considered a fatal flaw in a national forest plan EIS. The USFS' inflated assessment of market demand was successfully challenged in Natural Resource Defense Council v. USFS, 421 F.3d 797, 811-12 (9th Cir. 2005) We think the same flaw exists in this plan, wherein the market demand is deflated to the point that it is misleading. The PTSQ is what the USFS wants to offer over the long term, not what the industry needs to survive or maintain itself at the existing level.

- The DEIS refers to Daniels (2015) inconsistently throughout the document. Initially the "Daniels (2015)" format is used 22 times between pages 2-8 to 3-347, implying this is a final report. A variation that appears once is "(Daniels et al 2015)" on page 3-313. One must review the References on page 6-14 to see this actually refers to an "Unpublished Draft Methodology." Appendix G of the DEIS then refers 27 times to a "Daniels et al. (in press)" and includes a different title in the Citations on page G-9 of the DEIS. Are these actually two different references, or do they refer to the same unpublished manuscript?

- Please explain why the DEIS uses 25- and 100-year timeframes for comparison purposes. The use of those timeframes is misleading to the public. The lifespan of a Forest Plan is 15 years. A forest plan must show volumes for PWSQ (Projected Wood Sale Quantity) and PTSQ (Projected Timber Sale Quantity) for two decades per USFS Handbook direction. Based on this requirement, analysis and comparison of alternatives should be

based on a 20-year period. Projecting that a Forest Plan and PTSQ will not change over 25- and 100-year periods is misleading especially for the Tongass. Page 1-2 and 1-3 of the DEIS provide a planning history for the Tongass. The first forest plan for the Tongass was completed in 1979; since then there has been at least six different forest plans for the Tongass and the annual sales quantity has gone from over 400 MMBF to 46 MMBF under the current DEIS. Over a 36-year period, the forest plan has been changed every six years. To project and compare alternatives and suggest to the public that implementation of forest management activities will not change over 25- and 100-year periods misleads the public and prevents the public from being able to provide informed comments on the Proposed Plan. Please revise with appropriate timeframes for comparison.

- Analysis for the DEIS should be based on a 20-year period that coincides with the PWSQ and PTSQ calculations. Analysis over longer timeframes should provide the public information on the continued effects of actions taken during the life of the Forest Plan (15 years) or the PTSQ projects for the first two decades.

- Another issue is the timeframe used in Daniel's draft Demand Study, which only projects timber demand for a 15-year period (2015-2030). Any demand study associated with a forest plan should be for the first two decades so that the projected wood sale quantity (PWSQ) and PTSQ can be developed. Note that the proposed PTSQ under the DEIS is less than the derived Demand for the three scenarios that Daniels develops (Table G-1 page G-6 DEIS Vol II). The PTSQ should at least be equal to the largest derived demand volume for the first two decades of the plan.

- The PTSQ developed for the Proposed Plan should have taken into consideration the following statement from the Timber Demand section of the DEIS:

    - *"In choosing the timber sale offer level, it is important to anticipate the consequences of decisions. In terms of short-term economic consequences, over-supplying the market is less damaging than under-supplying it. If more timber is offered than purchased in a given year, the unsold volume is still available for purchasing off-the-shelf or re-offered at a minimal investment. However, a significant shortfall in timber supply available for harvest can be financially devastating to the industry." (Pg. G-8, DEIS Vol. II)*

- The DEIS on page 1-5 under Need states, "that the transition should be implemented in a manner that preserves a viable timber industry that provides jobs and opportunities for Southeast Alaska residents." The DEIS needs to define "viable timber industry" and "existing industry." These terms need to be defined for the Forest Service to be able to

develop a Forest Plan that "preserves" or "retains" the timber industry in southeast, and to be able assess positive or negative changes in the timber industry resulting from implementing the transition.

Analytical Needs

The analysis within the DEIS needs strengthening. For example:

- Table 3.9-10 Existing Young Growth in Reserves and in Matrix Lands by Alternative is misleading in that the percentage in each column is the percent of the total amount of young growth (YG) on the forest, not its percentage based on the subsection it is in (Reserve or Matrix).

- In Alternative 2 in Table 3.9-10, the reserves contain 110,339 acres of YG. This alternative will harvest 47,136 acres or 42.7% of the YG acres within the reserves; the table shows that amount of harvest as only 10% of the total acres of YG. What are the effects to the reserve system if 42.7% of the YG within the reserves is harvested? YG stands within beach buffers and less than 800 foot in elevation have greater value for wildlife that YG stands above 800 feet in elevation, and they may have more value than old-growth stands depending upon the location of the old growth (OG).

Nowhere in the Economic and Social Environment section on wood products is there any discussion on the cost to harvest and produce a manufactured product, either lumber or biomass (see lumber price graph). Please provide this missing information.

- Note graphs on pages 3-482 and 3-483 (Net Revenue) Figure 3.22-17 is net revenue for OG and Figure 3.22-18 is net revenue for YG. When you add the values together for a five year period in most cases the total net revenue is negative in value. As an example, Alternative 5 (preferred alt.) in Years 16-20 (a period when the transition has been completed and YG makes up the majority of the volume being offered) the total net revenue sum is a negative $10 million. How can the USFS have a timber sale program that is negative value when Public Law 112-74, House Report 2055-257, Section 414 allows it only to offer positive value timber sales?

- Note the information under Financial Analysis on pg. 3-481. The DEIS uses pond log value (PLV) to determine net revenue.

    - Pond log values are the price a buyer would pay for a log at the mill site (selling value minus manufacturing costs). Logging and transportation costs and an amount for normal profit and risk are also factored into this value. These pond log

values represent the value to the purchaser and are net of Forest Service costs that would be incurred for National Environmental Policy Act (NEPA) preparation, sale preparation and administration, and engineering support. (DEIS pg. 3-481)

- Table 2.22-16 shows discounted net revenue by alternative. How can the USFS show positive net revenue based on the statement above when the USFS has been subsidizing its timber sale program for years? The USFS cost for sale preparation and support is approximately $104/mbf (2014 Saddle Lakes DEIS pg. 3-67).

- Real life example – (2014 Saddle Lakes DEIS chapter 3 Issue 1 – Timber Economics section pg. 3-62) In Table 5,they have taken the end sales value minus the total cost to create the end product and the result is a negative value in all but one alternative under the export policy scenario. What is labeled the indicated advertised rate is the stumpage return to the USFS and is before the USFS subtracts their administrative cost of $104/mbf.

- Another real life example – (Big Thorne Project, ROD 2013) Table ROD-9 on page 36 shows an indicated bid value for the selected alternative as $23.77 positive; again this is before the FS admin fee of $104/mbf is subtracted. Big Thorne includes both OG and YG volume.

- Using the discounted net revenue number for Alternative 5 from Table 3.22-16, the USFS is saying it will average a positive return of ~$98/MBF ($112.9 million divided by (46MM(annual volume) *25years)) over a 25-year period after subtracting its administrative cost.

According to 40 CFR 1502.23, when economics are relevant and important to a decision, economic information must be included in an EIS.

- The DEIS documents do not detail the PLV used by the USFS. What is the PLV number for YG? What is the PLV for OG? Nothing in the documents tells the reviewer how the USFS determined the PLV and cost of future harvest 25 and 100 years out. Did the USFS use a set percentage increase over time? Please provide this missing information.

- In Appendix B (pg. B-13) when they performed the modeling exercise they used only the five southern districts on the Tongass for the first 15 years. By not considering/using the entire Tongass they misrepresent the actual cost of harvesting timber from the forest. See TWFG paper, *Analysis of Old Growth Inventory and Land Base Available for Operations within the Tongass National Forest, 2014*. In that document the cost of transportation

from the northern part of the Tongass to the Viking mill in Klawock drives most volume available for harvest into negative value territory.

- Based on the Woodstock model (see attached TWFG sheet) for Alternative 5 and the statement on pg. 2-32 of the DEIS, by year 16 the volume of OG harvest will be reduced to 5MMBF per year or a total of 25MMBF for the period years 16-20. The Woodstock model shows the 25MMBF of OG producing a net return of $360.99/mbf. Refer to the net returns for Saddle Lakes and Big Thorne; the USFS has not produced an OG timber sale that generates a net return after administrative cost of $360.99.

Corrections or Revisions Needed

Page 3-450, DEIS: Table 3.22-5 shows the average timber harvest for State lands is 25.7 MMBF for the last 13 years; the average for the last seven years is a much lower 12.3 MMBF. The last seven years is a better indication of future volume based on the fact that Alaska Mental Health Trust and the University are not bound to manage on a sustained-yield basis.

Page C-4, DEIS: Table C-1 breaks down past road construction and states that 3,379 miles out of 3,660 miles of roads constructed on non-national forest land remain open. Based upon the Division of Forestry's best estimate, instead of 92% remaining open, the total still open is more likely in the range of 1500-2000 miles, or about 50%.

Additions

Since this amendment process is driven by Memorandum 1044-009 – July 2, 2013, consider including the memorandum in the Appendix of the DEIS, or at least the two quotes below:

- *"To accomplish the transition to a timber program based primarily on young growth, it is important to retain the expertise and infrastructure of the existing industry so businesses can quickly re-tool. These businesses are fundamental to both the young growth and restoration components of the future timber program, and to the economic vitality of the region. Such an approach requires a reliable supply of economically viable timber, with the old growth component decreasing over time while the young growth component increases."*

- *"To ensure a smooth transition, the Forest Service will continue to offer a supply of old growth timber while increasing the supply of young growth to provide industry in Alaska the opportunity to develop new markets, learn new skills, and acquire new equipment. The continuation of limited sales of old growth timber is essential to maintain the existing industry until young growth can efficiently be processed."*

WILDLIFE[2]

The Alaska Department of Fish and Game (ADF&G) reviewed USFS alternatives accommodating the transition from old-growth to young-growth timber harvest and looks forward to participating in future interagency review of the young-growth monitoring plan. ADF&G recognizes the value to wildlife in transitioning to young-growth forest management while maintaining sufficient old-growth forest to support sustainable and harvestable populations of old-growth associated birds and mammals.

Wolves

ADF&G supports additional research and analyses concerning the effect of the Proposed Plan on Alexander Archipelago wolves. The State has primary trust authority for managing wolves and the USFS has land management authorities to provide habitat and access management for wolves in cooperation with the state. Conservation of wolves in this area warrants additional consideration in the Forest Plan.

Sealaska Land Exchange and the Old Growth Reserve System

The Old Growth Reserve (OGR) system was first established in the 1997 Forest Plan as the primary component of the wildlife conservation strategy with the intent of providing habitat sufficient to maintain sustainable, well-distributed populations of old-growth associated species. The OGR system is particularly important for maintaining populations of old-growth associated species in areas where much of the old-growth forest has been harvested. The Southeast Alaska Native Land Entitlement Finalization and Jobs Protection Act transferred land out of the Tongass National Forest to Sealaska Corporation including lands within existing OGRs. The USFS worked with ADF&G and others to create new or modified OGRs for affected areas of the Tongass National Forest from remaining productive old growth (POG). A report on that effort is included in Appendix D of the DEIS.

Although Appendix D of the DEIS states that a review of the scientific basis for the current conservation strategy is outside the scope of this amendment, ADF&G recommends the USFS use its science review process to assess the new and modified OGRs before issuing the Final Environmental Impact Statement (FEIS). If the review of the modified OGRs indicates they are unlikely to meet the OGR system intent, especially in heavily-logged areas, and more old-growth logging occurs on nearby USFS land, the opportunity to create a more effective system in those areas may be lost.

[2] The State of Alaska point of contact for fish, wildlife and subsistence-related comments on the Proposed Plan and DEIS is Greg Albrecht with ADF&G's Division of Habitat. He can be reached at greg.albrecht@alaska.gov or 907-465-6384.

Young-Growth Management

Page 3-215 through 3-217, DEIS: Please provide more information on benefits to wildlife from precommercial thinning. Explain the assumption that reestablishing old-growth characteristics will benefit wildlife by discussing benefits and losses to species groups, and describe how recurring thinning treatments will affect those groups prior to reaching old-growth characteristics or harvest. Please clarify the terms *maintain* and *improve* with regard to wildlife habitat by providing or referencing a standard of what it means to maintain or improve.

We recommend the USFS articulate how young-growth management will benefit wildlife. Depending on the species and phases of their natural history, some species may benefit from the young-growth management, while others may not. The Forest Plan should address the state of knowledge regarding the proposed management scheme for at least the management indicator species (MIS), provide a quantitative assessment of the most likely effects of second growth management for individual wildlife species, and provide a qualitative assessment of effects where no quantitative assessments are possible.

Page 3-215 through 3-217 and 3-245, DEIS: Please include outputs (e.g. deer/mi^2) from the habitat suitability index model at the wildlife analysis area level so that finer scale analyses can be made in areas where extensive old-growth harvest was conducted. We caution using the FRESH model, with which ADF&G is not familiar, prior to field verification. Please include more information in Chapter 3 about the FRESH model and its assumptions. Also, clarify how habitat quality is expected to improve after 25 years following thinning prescriptions (DEIS Table 3.10.11).

Specific Comments on the Proposed Plan and DEIS

Page 2-7, Wildlife, DEIS: Please consider managing habitat to provide for sustainable wildlife populations rather than viable populations.

Page 2-8, Wildlife, Proposed Plan: Replace the term *sport* with *hunting.*

Page 2-14 through 2-20, Alternative 2, DEIS: Please provide a clearer description of how harvest in the beach buffer occurs. Include discussion of the anticipated effects on MIS when the 1,000 ft beach buffer is removed for harvest and road construction. Please expand the discussion of how leaving an adjacent inland stand of POG or young growth serves the purpose of the beach buffer. It would be helpful to focus this discussion on biogeographic provinces 13 and 14. See our similar comments for Appendix D on page 4.

Page 3-10, Desired Condition, paragraph 1, Proposed Plan: Define appropriate research, how the determination is made, and what role the state plays in the process.

Page 3-45, Proposed Plan: Consider adding a land use designation (LUD) standard and guideline under the wildlife habitat improvement heading that addresses non-native wildlife management following a natural disturbance or disease.

Page 3-67, Desired Condition, Proposed Plan: Clarify how a population of a species is defined as a subspecies. Consider revising the definition on page 7-92 and consult the ADF&G draft Wildlife Action Plan for more information on subspecies (2015).

Page 3-138, Wildlife, Proposed Plan: Please clarify the author and standing of the Tongass Young Growth Management Strategy referenced here. The document could be strengthened by adding more information regarding the effects of the strategy to wildlife. The version available through the references (Page 6-49, DEIS) does not contain Exhibit 3.

Page 3-223, DEIS: Please update this section to reflect the Fish and Wildlife Service decision announced on January 5, 2016 that the Alexander Archipelago wolf does not warrant protection as an endangered or threatened species under the Endangered Species Act.

Page 4-96, Proposed Plan: We recommend adding standards and guidelines for protection of the Pacific marten *Martes caurina*, which is endemic to Admiralty and Kuiu Islands. Macdonald and Cook (2007) and Dawson (2008) are good resources.

Page 4-100, DEIS: We recommend eliminating the distinction between peregrine falcon subspecies given recent studies about the subspecies status along parts of coastal Alaska.

Page 4-99, Proposed Plan: Please replace goshawk nest stand with nest site. The monitoring protocol could be strengthened by ensuring the assumptions of nest identification and the probability of detection is valid. ADF&G biologists are interested in helping USFS biologists develop the monitoring program. We are concerned about the efficacy and statistical validity of the current goshawk monitoring program.

Page 5-8, Management Approaches, Proposed Plan: This section would benefit from clear goals and objectives related to monitoring the effects of young-growth harvest on MIS. See our similar comments for Appendix D on page 4.

<u>Appendix D of the DEIS</u>

Page D-3: This section summarizes the scope of analysis and acknowledges new science. As in the DEIS, the analysis does not adequately describe how young-growth harvest affects wildlife species. Similarly, the DEIS and the section on the contribution of matrix lands lacks adequate analysis and should be strengthened with references from land management focused research conducted on the Tongass.

Page D-4, paragraph 2, DEIS: Stating young growth serves as dispersal corridors between old-growth stands is a generalization, as young-growth stands can be barriers rather than corridors for some old-growth associated species. Please revise.

Page D-5, paragraph 3: The USFS states that on a forest-wide basis, over 90% of the existing POG will be protected from harvest. Given the context, this statement implies that forest management will have little effect on old-growth associated species because 90% of their habitat will remain intact. However, populations of many old-growth associated species are confined to islands or biogeographic regions where a much higher proportion of POG has been or will be harvested. We recommend that relative to wildlife, such habitat summaries be presented at a scale that is meaningful to the species or populations being discussed.

Page D-5, paragraph 4: To help the reader get a better sense of the scale of changes resulting from GIS mapping updates, please add text and a table describing how the changes affected the wildlife habitat analysis. For example, provide the number of polygons/acres in a given bioregion found to be >150 years old and corrected to size class 4, resulting in increased POG acreage in a bioregion.

Page D-12: Please provide a clearer description of how harvest in the beach buffer occurs under Alternative 2. Include discussion of the anticipated effects on MIS when the 1,000 ft beach buffer is removed for harvest and road construction. Please expand the discussion of how leaving an adjacent inland stand of POG or young growth serves the purpose of the beach buffer. It would be helpful to focus this discussion on biogeographic provinces 13 and 14, which have the highest level of this type of harvest under Alternative 2. See our similar comments for the DEIS on page 3.

Page D-17, paragraph 4: Please clarify the statement that individual islands function as metapopulations for some species.

Page D-18, paragraph 7: This section would benefit from clear goals and objectives related to monitoring the effects of young-growth harvest on MIS. See our similar comments for the DEIS on page 3. ADF&G is available to help develop the monitoring questions.

FISH

Ongoing USFS monitoring results show existing standards and guidelines protecting riparian areas and fish habitat are largely effective. ADF&G recognizes the need to provide bridge timber for the transition to young growth which may require short-term relaxations of conservation strategy elements. We encourage simple, measurable, replicable methods to ensure monitoring is

completed and results are useful. ADF&G biologists look forward to being involved with these monitoring efforts.

Page 3-31, DEIS: Include discussion and citation of literature regarding how increased harvest in the riparian management area (RMA) in moderate vulnerability karst landscapes could impact diffuse recharge and stream water quality.

Page 3-103, DEIS: Include discussion and citation of literature regarding potential changes to windfirmness due to thinning in the RMA.

Page 3-103, DEIS: Include discussion and citation of literature regarding how a reduction of the RMA width could affect wood recruitment where average tree heights exceed 100 ft.

Page 3-118, paragraph 5, DEIS: Consider strengthening the discussion by citing recent research on rainbow trout and steelhead *Onchorhynchus mykiss* (Kendall et al. 2015, Pearse et al. 2009, Sloat and Reeves 2014a, Sloat and Reeves 2014b).

Page 3-123, DEIS: Please clarify the circumstances where substantially more RMA group selection could occur, and how many acres would be acceptable under this alternative given the standards and management approaches in the riparian section of Chapter 5.

Page 3-126, paragraph 2, DEIS: Consider removing the statement:

Some negative effects, or more appropriately, increased risk, to the natural range of variation in stream processes and fish habitat would likely occur by management activities over the long term for all alternatives. The extent of harvest activity and associated road development are likely to result in decreases of some fish populations in managed watersheds.

This is speculative and contradictory to the statement in the first two sentences of the third paragraph page 3-126. The presence of *risk* should not be confused or used interchangeably with *negative effects,* in the absence of supportive research. We recommend removing the association between *risk* and *negative effects* to fish habitat from the DEIS. The concept that *risk* is both normal and being fully mitigated in the Tongass should be added to the DEIS with discussion of Dr. Doug Martin's body of research, cited elsewhere in the DEIS.

Page 5-8, S-YG-BEACH-03, Proposed Plan: In some locations, such as estuaries, the forest edge could be greater than 200 feet from mean high tide and it is not clear whether or not this buffer includes non-forest acreage. If the standard is intended to include non-forested acreage, please include in the FEIS an evaluation of compatibility with the proposed desired conditions of the beach and estuary fringe in Chapter 5 and the forest side standards and guidelines in Chapter 4. If the standard is intended to include forested acreage only, we suggest modifying the first sentence

of the standard to *Commercial harvest in the beach fringe is not allowed within a minimum 200-foot buffer beginning at the forested edge above the mean high tide line.*

Page 5-9, Proposed Plan: A 10-acre opening in the RMA outside of the Tongass Timber Reform Act buffer appears contradictory with desired condition DC-YG-RIP-01, the fish and riparian standards and guidelines of Chapter 4, and Appendix D. Given the desired condition in DC-YG-RIP-01 is to improve functions for soil, water, fish, wildlife, and other resources, while also providing a commercial byproduct, please explain where a 10-acre opening would improve conditions and be approved at the project level, especially if there is no requirement to thin the RMA following harvest. If the assumption in Alternative 5 is that timber can be harvested in such a matter from the RMA, the FEIS should describe instances when a 10-acre opening in the RMA could be implemented so that decision makers understand whether or not this wood source is a reliable element of the alternative.

Page 5-9, Proposed Plan: Alternatives 2 and 5 allow removing up to 35% basal area of a stand in the RMA. Consider adding a standard in the Chapter 5 riparian section to clarify how the 35% removal can be distributed across the stand and if harvest can be focused in the RMA.

Page D-19, Table 8 DEIS: Consider adding a row in the table showing projected young-growth acreage suitable for harvest in development LUDs following proposed changes to the scenic integrity standards and guidelines and the application of the rules surrounding harvest prior to the culmination of mean annual increment. This would provide perspective when evaluating the necessity to conduct harvest in environmentally sensitive areas by showing the relative gains in available timber from all components of each alternative.

Page 4-10, Section III, Proposed Plan: Add a reference for the 2015 *Fish Stream Identification and Stream Classification on the Tongass National Forest* document and its associated field guide, which include results of recent working groups and field verification studies.

Page 5-7, paragraph 5, Proposed Plan: Consider including prioritization of stewardship fund use on the district where they were generated, a process made easier by Public Law 108-148-DEC.

Page D-12, paragraph 3, DEIS: Improve clarity by beginning the first sentence with *Of the action alternatives.*

Page D-12, paragraph 3, DEIS: Consider revising the statement in the last sentence about effects being short-term and localized, which contradicts the statement on page D-11, paragraph 4.

Page 3-98, Table 3.6-2, DEIS: Suggest changing the title to *Commonly targeted sport, subsistence, and commercial fish.* The existing title is misleading since sport fishing for steelhead in the region is primarily catch-and-release.

Page 3-104, paragraph 1, DEIS: Specify the harvest type discussed in the second sentence.

Page 3-108, paragraph 2, DEIS: Angler days (Table 1), recorded in ADF&G's statewide harvest survey data, better represent fishing effort trends than license sales. The data is available at: http://www.adfg.alaska.gov/sf/sportfishingsurvey/index.cfm?ADFG=region.home.

Table 1.–Angler days by water type among Southeast Alaska communities, 1996–2014

Year	Freshwater	Saltwater	Total
1996	72,459	297,960	370,419
1997	93,478	346,320	439,798
1998	75,445	295,302	370,747
1999	99,054	435,610	534,664
2000	106,355	435,052	541,407
2001	98,093	409,148	507,241
2002	101,563	367,739	469,302
2003	107,755	369,437	477,192
2004	104,166	443,083	547,249
2005	102,200	465,584	567,784
2006	104,834	412,001	516,835
2007	104,431	435,859	540,290
2008	100,094	409,503	509,597
2009	96,343	403,738	500,081
2010	87,279	356,572	443,851
2011	95,332	352,276	447,608
2012	91,009	387,998	479,007
2013	83,871	462,179	546,050
2014	95,068	469,242	564,310

Page 3-328, Table 3.15-7, footnote 6, DEIS: Please include the data source for the ADF&G ratings.

Page 3-343, Fishing, DEIS: Please provide a citation for the statement *13 percent of inventoried recreation places acres are currently important for fishing*.

SUBSISTENCE

Pages 3-97 through 3-101, DEIS: This section includes a general characterization of the magnitude of sport and commercial fish harvests from Conrad and Gray (2014). The FEIS should include similar information for subsistence harvest presented in Conrad and Gray (2014). Page 3-390, first paragraph under abundance and distribution, DEIS: The ADF&G (2014) citation is inaccurate. Please cite the 1987 Tongass resource use cooperative survey (TRUCS), which provides the only survey data for Tenakee Springs and Skagway.

Pages 3-533 through 3-635, DEIS: In the subsistence sections of the Elfin Cove, Gustavus, Meyer's Chuck, Metlakatla, Pelican, Port Alexander, Skagway, and Tenakee Springs individual community assessments, the 1987 ADF&G harvest data are referenced as distinct from the TRUCS data presented in Kruse and Frazier (1988), but the information in both references is from the same study. Citations in these sections presenting the data from both publications should be reconciled.

Page 3-508, third paragraph, DEIS: Prince of Wales communities are listed as using a combination of hydroelectric and diesel-generated power while the individual community summaries indicate power is generated by diesel only. Please clarify.

Pages 3-513 through 3-654, DEIS: Please include a citation for the source of information presented in the community use area maps for all communities. If maps are based on the 1987 TRUCS harvest data, please include an analysis of how uses may have changed in the last 30 years.

Pages 3-542 through 3-43 and 3-560 through 3-561, DEIS: The Haines and Hyder individual community assessments focus on potential impacts to local resident deer harvests, however, moose are more important for these residents, unlike most other southeast communities. Please modify the assessments to include the importance of moose in these communities.

Pages 3-568, 3-599, and 3-653, DEIS: The Kake, Pelican, and Yakutat individual community assessments specify several subsistence use areas as most important or very important. Please provide a definition for these subjective terms, or eliminate them.

Page 3-550, DEIS: Update this section to include recent completion of the Gartina Falls Hydroelectric facility in Hoonah.

Page 3-604, DEIS: In the Petersburg Subsistence section, replace land mammals (mostly deer) with deer, to be consistent with information for other communities regarding the TRUCS data.

Page 3-612, first paragraph: Replace Pelican with Port Alexander.

TRANSPORTATION[3]

Elimination of the TUS LUD violates USFS planning regulations and NEPA.

The most significant proposed amendment to the 2008 Tongass Land and Resource Management Plan is the elimination of the Transportation and Utility Systems Land Use Designation (TUS LUD). Under the current plan, the TUS LUD depicts specific geographic corridors connecting the communities located within the boundaries of the Tongass National Forest. These corridors are intended to be developed and operated as transportation and utility systems in accordance with the State of Alaska's Southeast Alaska Transportation Plan (SATP). The State of Alaska holds transportation and utility easements to develop and operate the public infrastructure connecting these communities by way of a reciprocal exchange of easements with the United States, which was enacted by Congress in the Section 4407 of SAFETEA-LU (P.L. 109-59), the 2006 federal transportation bill. In December 2015, Congress passed the latest federal transportation bill (FAST Act, P.L. 114-94), which clarified a "perceived defect" in Section 4407 and expressly granted to the State the transportation and utility easements linking the communities of Southeast Alaska. Senate Report 114-80 (July 15, 2015) at pages 23-24. The elimination of the TUS LUD, as proposed in the amendments, would remove specific geographic management areas from the Forest Plan, which would violate USFS planning regulations and would violate the requirements of the National Environmental Policy Act (NEPA).

Elimination of the TUS LUD requires a plan revision, rather than a plan amendment.

Under USFS planning regulations, a plan may be amended "to add, modify, or remove one or more plan components, or to change how or where one or more plan components apply to all or part of the plan area." 36 CFR § 219.13. The plan components are guides for future project activities which include: (i) desired conditions; (ii) objectives; (iii) standards; (iv) guidelines; and (v) suitability of lands. 36 CFR § 219.7. Each plan component may apply "to the entire plan area, or to specific management or geographic areas." *Id.* Thus, a plan amendment may change

[3] The State of Alaska primary contact for Proposed Plan and DEIS comments related to transportation is Roger Healy of the Alaska Department of Transportation & Public Facilities. Roger can be reached at roger.healy@alaska.gov or 907-465-6958.

how a geographic area (i.e., a LUD) is managed in the National Forest, but it may not add or eliminate a management area or geographic area from the plan.

The designation or elimination of a management area or geographic area from an existing plan must be done through a plan revision. 36 CFR § 219.7(c) and (d). The administrative and public processes for a plan revision are separate and different from the processes required for a plan amendment. 36 CFR §§ 219.7(c) and 219.13(b). The USFS' attempt to eliminate the TUS LUD through a fast-track plan amendment violates the regulatory processes that are designed to ensure a reasoned and deliberative consideration of proposed modifications to planning areas or geographic areas in forest plans. 36 CFR §§ 219.7(c). As the USFS has not commenced or undertaken the required administrative and public processes for the elimination of the TUS LUD, the elimination of the LUD would violate the National Forest Management Act and the implementing regulations.

<u>Elimination of the TUS LUD requires public notice and compliance with NEPA.</u>

The stated purpose and need for the Proposed Plan amendments is to enable the transition to young-growth timber harvest management as directed by the Secretary's 1044-009 Memorandum. Elimination of the TUS LUD does not fulfill or further the stated purpose of the proposed plan amendments, and the proposed action was not disclosed as a secondary purpose for the plan amendment. During the scoping process, the USFS identified four significant issues that were to be analyzed in depth as there were "disagreements about the best way to use a resource." DEIS, page 1-9. Those significant issues are:

1. Young Growth Transition;
2. Renewable Energy;
3. Protection of Roadless Areas; and
4. Protection of Wildlife Habitat and the Old Growth forest.

Quite notably, neither the published notice of intent nor the DEIS purpose and need statement disclose the intent to eliminate the TUS LUD. The elimination of the existing management prescriptions for Southeast Alaska's transportation and utility corridors is unnecessary and counterproductive. If the USFS intends to consider and debate 'the best way to use' these transportation and utility corridors, the National Environmental Policy Act (NEPA) requires the significant federal action be disclosed and fully analyzed prior to implementation.

<u>The Proposed Plan and DEIS grossly underestimate development in the TUS LUD.</u>

The USFS draws an unsupported conclusion that "[t]here is considerable uncertainty concerning the future development of Southeast Alaska's road system." DEIS, p. 3-278. This statement is

particularly confusing, as an array of present and reasonably foreseeable transportation projects are identified in the cumulative effects analysis. DEIS Appendix C. Just in the category of highway development projects: construction of 32.3 miles of highway in the TUS LUD were recently completed; 140.6 miles of highway are funded for design and construction; and 15.7 miles of highway are funded for environmental permitting and design. These multiple highway projects are indicative of the State of Alaska's robust delivery of improved transportation infrastructure to Southeast Alaska—there is no uncertainty in these actions.

Development and delivery of transportation projects in the established transportation and utility corridors is accomplished, in part, by the stability and predictability of the geographically designated TUS LUD. The USFS' proposed objective to "Cooperate with other agencies in developing 35 miles of transportation corridors on NFS lands during the 15 years after plan approval [Proposed Plan, 5-14]" appears extremely limited and quite contradictory to the many upcoming and reasonably foreseeable highway projects. With nearly 200 miles of state highway construction recently completed and planned for the near future—and congressionally granted easements underlying hundreds of miles of the TUS LUD—the USFS's proposed objective does not reflect the planned development in the TUS LUD.

<u>The Proposed Plan could benefit by adding new components **in addition to** TUS LUD.</u>

The DEIS expresses a need to support development of renewable energy and perhaps to include power transmission corridors in the new Renewable Energy Direction (RE) component. It is easy to imagine that renewable energy projects, including support roads and power transmission lines, will need to branch from and be located outside the TUS LUD corridors. To ease the development of those discrete projects, the RE component and the Transportation Systems Corridor Direction (TSC) component may prove workable for the USFS. However, for the multiple-agency and multiple-year planning required to connect the communities of Southeast Alaska, the State requires that the forest plan recognize the Section 4407 easements and the SATP corridors in the existing TUS LUD. The Forest Plan must make the distinction that the new RE and TSC components are designed for, and apply to developments outside the TUS LUD.

The DEIS and proposed plan amendments explain that the geographically specific TUS LUD is being eliminated and replaced with area wide plan components for the new TSC. The purpose of the plan direction for TSC is to facilitate the availability of NFS land for the development of existing and future transportation systems. However, the rationale for this change is not clear nor was it developed as an issue that required addressing. It is unclear how eliminating the TUS LUD will better facilitate the availability of NFS land for the development of existing and future transportation systems, since the State currently holds easements over the vast majority of the TUS LUD. The depiction of the corridors on the TUS LUD maps in the 2008 plan was

informative and consistent with the management direction in the plan concerning the priority of TUS development in those corridors. The removal of the TUS LUD corridors from the Proposed Plan's maps is a significant change that does not seem either necessary or productive. Removal appears to be counterproductive particularly given that the corridors were incorporated into the 2008 Forest Plan, but now the same corridors identified in the SATP appear to be only referenced as examples of corridors that might be constructed in the national forest. The elimination of TUS LUDs eliminates any attempt to recognize and reserve corridors for this potential future land use. It removes any current effort to identify the need of specific corridor reservations and to inform other current and potential land use of corridor reservations. Removal of the TUS LUD will likely have the effect of making NSF land less available, create future use conflicts, and deter development of existing and future transportation systems.

The proposed revision to the plan is confusing in that it repeatedly states that transportation and utility systems are not precluded anywhere in the Tongass Nation Forest under the provisions of Public Law 109-59 and ANILCA Title XI. That statement masks a great deal of information. Section 4407 of Public Law 109-59 granted transportation and utility easements within specific corridors that are recognized by the TUS LUD; ANILCA Title XI provides a process wherein a transportation and utility easement may or may not be granted. Since the State currently holds property rights in the corridors identified in the TUS LUD, the LUD must be preserved. The State could pursue infrastructure development outside the TUS LUD, under ANILCA or other authorities, but that would be a somewhat unusual or rare occurrence. The new RE and TSC components may prove useful in that unusual circumstance; however, for development of infrastructure connecting the communities in the Tongass, the State, regulatory agencies, and the public require the disclosure and predictable management of the transportation and utility corridors in the TUS LUD.

<u>There is no management advantage by replacing TUS LUD with a new TSC component.</u>

Under the current plan, the TUS LUD guarantees precedence of transportation and utility development goals over the goals and management prescriptions of an underlying LUD crossed by the TUS LUD by stating "The Transportation Utility System (TUS) LUD takes precedence over any underlying LUD (subject to applicable laws) regardless of whether the underlying LUD is a TUS Avoidance LUD or not. As such, it represents "a 'window' through the underlying LUD through which roads and/or utilities can be built." This is an ideal LUD to manage a property interest and development interest that may not spring to life for years or decades to come. The express purpose of the TUS LUD was to minimize potential conflicts with underlying LUD goals and associated management prescriptions should transportation development occur. The LUD flags in advance specific areas of land use goals conflicting with those of future potential transportation and utility development, though the goals objectives and management standards and guidelines of the TUS LUD do not spring into existence until

commencement of construction of the transportation or utility facility. The TUS LUD provides predictability and transparency.

The proposed plan amendment is designed to eliminate the TUS LUD and the specific geographic corridors where the management prescriptions of the TUS LUD apply. The Proposed Plan and the DEIS explain that the TSC components will take precedence over LUD-specific standards and guidelines throughout the Tongass National Forest, but those statements give little comfort when the specific property and development rights granted by Congress and recognized in the TUS LUD are removed from the plan. While the State recognizes that the TSC component and the RE component may provide clarity for potential development outside the TUS LUD, all but the smallest fraction of infrastructure development in Southeast Alaska will occur within the TUS LUD. To provide the predictability and transparency necessary for the continued development of the infrastructure connecting the communities of Southeast Alaska, the TUS LUD must be preserved.

General Plan comments by section:

Chapter 1 Introduction

Proposed Plan page 1-5 second to last paragraph states: "The communities of Southeast Alaska depend on the Tongass National Forest in various ways, including employment in wood products, commercial fishing and fish processing, recreation, tourism, and mining, and mineral development." The paragraph also goes on to explain the importance of subsistence resources; however, overlooked is the importance of public access to the forest by all modes including maintenance of forest roads. We recommend including in the introduction a sentence describing the importance and role of public access and transportation infrastructure.

Chapter 2 Goals and Objectives

No mention is made under **Forest Desired Conditions** of transportation utility system goals and objectives.

Recommend the inclusion statements of desired conditions for development and maintenance of regional and area transportation - utility systems:

- Provision and maintenance of air and marine access points and associated infrastructure by the Forest Service, including a system of forest trails and road to facilitate access to forest areas managed for timber harvest and various multi-uses including recreation, subsistence and administration of the forest.

- A State of Alaska maintained multi-modal regional transportation system of airports, marine docks and floats, and road system supporting access to and through the National Forest providing efficient and essential transportation between communities within the forest and between the forest and the rest of the world in support of the area economy.

Under **Forest-wide Multiple-use Goals and Objectives** recommend the addition of the above as goals under a category referred to as "Access." Similar access objectives should be listed under and in support of the following categories:

- Local and Regional Economies
- Minerals and Geology
- Recreation and Tourism
- Renewable Energy
- Subsistence and
- Timber

Recommend redefining "Transportation" as a category supporting the following Goal:

- Development and operation of transportation and utility infrastructure within the "Transportation Utility System" corridors linking the communities of Southeast Alaska as provided by Section 4407 of P.L. 109-59, as amended by P.L. 114-94, and as allowable under ANILCA Title XI.

Chapter 3 Management Prescriptions

Do not replace the overlay Transportation Utility System (TUS) overlay Land Use Designations (LUD) as described in the 2008 Forest Plan. Retention of the TUS LUD is needed to physically locate TUS corridors established by law, replete with goals and management prescriptions having precedence over the underlying LUDs.

LUD Management Prescriptions:

ADD TUS LUD overlay LEVEL ONE precedence to other LUDs in the following categories:

SPECIAL INTEREST AREA LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

B. Coordinate interpretation of the unique values of the Special Interest Area with management of transportation infrastructure in TUS LUD corridors and the rights-of-way of other publicly-owned roadways.

REMOTE RECREATION LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

A. (*revise*) New roads are not permitted, except *within a TUS LUD and* to access authorized mineral operations (or as excepted under Lands).

MUNICIPAL WATERSHED LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

A. (*revise last sentence*) New road construction is generally inconsistent with Old-growth Habitat LUD objectives, but new roads may be constructed if *within a TUS LUD*. Forest roads may occur in this area with due consideration for protection of the watershed.

OLD-GROWTH HABITAT LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

A. (*revise*) New road construction is generally inconsistent with Old-growth Habitat LUD objectives, but new roads may be constructed *if within a TUS LUD, or if a forest road with no feasible alternative.*

B. Add: 4. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

SEMI-REMOTE RECREATION LUD under TRANSPORTATION, Transportation Operations, TRAN, add:

A. (*revise***) Where Semi-Primitive Motorized recreation opportunities are emphasized, existing low standard roads are generally managed for use by high clearance or OHVs, snowmobiles, or motorcycles subject to an approved Access and Travel Management Plan. Generally, new roads are not constructed in this area, except *within a TUS LUD and* to link existing roads or provide access to adjacent LUDs.**

Add : *4. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

LUD II Page 3-68 under Objectives add bullet: *Roads and utility lines are allowed within a TUS LUD.*

Page 3-72 under Transportation Operations: TRAN: add *3. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

WILD RIVER LUD page 3-74 add under Objectives: *Permit road and utility lines allowed within a TUS LUD.*

Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-80 (add) *D. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

SCENIC RIVER LUD page 3-87 TRANSPORTATION, Transportation Operations: TRAN
Add: *5. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

RECREATIONAL RIVER LUD page 3-87 TRANSPORTATION, Transportation Operations: TRAN

Page 3-94 add: 3. Roads and utility lines allowed under a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.

EXPERIMENTAL FOREST LUD page 3-100 TRANSPORTATION, Transportation Operations: TRAN

Add: *C. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

SCENIC VIEWSHED LUD

Add under Objectives page 3-101: Roads and utility lines are allowed under a TUS LUD.

TRANSPORTATION, Transportation operations: TRAN, page 3-108

Add: *6. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

MODIFIED LANDSCAPE LUD page 3-109 add under Objectives: *Roads and utility lines allowed within a TUS LUD.*
Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-115 (add) *6. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

TIMBER PRODUCTION LUD page 3-116 add under Objectives: *Roads and utility lines allowed within a TUS LUD.*

Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-122 (add) *5. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

MINERALS LUD page 3-123 add under Objectives: *Roads and utility lines allowed within a TUS LUD.*

Under TRANSPORTATION, Transportation Operations, TRAN, add:

Page 3-128 (add*) E. Roads and utility lines allowed within a TUS LUD. Roads under the jurisdiction of the Alaska Department of Transportation and Public Facilities shall be managed in accordance with the State of Alaska's best management practices.*

Chapter 4 Standards and Guidelines

Reinstate standards and guidelines for the overlay Transportation Utility System (TUS) Land Use Designations (LUD) as described in the 2008 Forest Plan with corridor goals and management prescriptions having precedence over the underlying LUDs.

Chapter 5 Plan Content Developed Under the 2012 Planning rule

Revise the Transportation System Corridor (TSC) to apply solely to development and maintenance of forest roads located outside of the TUS LUD corridors or under the jurisdiction of the U.S. Forest Service.

Chapter 6 Implementation

No comments.

Appendices A – K

No appendix on transportation was developed or included. With a proposed major revision, such as the elimination of LUD, it would be helpful to review the analysis and decision-making that supports the major federal action.

ALASKA NATIONAL INTEREST LANDS CONSERVATION ACT[4]

Wild and Scenic River Management

ANILCA amended the Wild and Scenic Rivers Act and designated 26 Wild and Scenic Rivers and an additional 12 rivers designated for study. There are currently no designated rivers on the Tongass National Forest, and pursuant to ANILCA Section 1326(b)[5], Congress has since provided no further direction to the Forest Service to conduct additional Wild and Scenic River studies in Alaska.

We appreciate the proposed plan does not include new wilderness and wild and scenic river reviews or recommendations. However, we remain concerned that, despite explicit direction in ANILCA Section 1326(b) to not conduct such studies, the USFS continues to manage the 32 rivers recommended in the 1997 Forest Plan Record of Decision to maintain their eligibility for designation at some distant future date as wild and scenic rivers.

The plan indicates such management will continue until Congress takes action; however, the plan does not disclose any details on how or when the recommendations were submitted to Congress and what occurred subsequent to the submittal. We do not support protective management for recommended rivers that resulted from a study conducted in violation of ANILCA, nor do we

[4] The State of Alaska point of contact for ANILCA comments on the Proposed Plan and DEIS is Sue Magee with DNR's Office of Project Coordination and Permitting. She can be reached at susan.magee@alaska.gov or 907-269-7529.

[5] ANILCA Section 1326(b) **No further studies** of Federal lands in the State of Alaska for the single purpose of considering the establishment of a **conservation system unit**, national recreation area, national conservation area, or for related or similar purposes shall be conducted **unless authorized by this Act or further Act of Congress**. (Emphasis added)

support applying management prescriptions on that basis indefinitely. We therefore request the corresponding Wild, Scenic and Recreational LUDs either be removed from the plan or only applied after a river is designated by Congress. Further, we request the plan include specific information about the recommendations' submittal to Congress and any subsequent actions taken by Congress in response.

ANILCA Section 810 Analysis

The DEIS states that an 810 evaluation and determination is not required because this is a programmatic amendment. However, the DEIS not only evaluates the impacts to subsistence, citing a "significant possibility of a significant restriction, resulting from a change in competition" (p. 3-394), the Service is also holding subsistence hearings. For clarity and compliance with ANILCA, we recommend the Service include a full 810 evaluation in the plan. We note the information is largely already contained in the DEIS.

Page-specific Comments

Page 3-10, Proposed Plan: We support the proposed decision to reference Title XI of the Alaska National Interest Lands Conservation Act (ANILCA) in the Wilderness LUD Standards and Guidelines. This change will ensure that the full context and process required in ANILCA is considered and followed when transportation and utility projects are proposed within conservation system units designated by ANILCA on the Tongass National Forest (i.e. designated Wilderness).

Page 3-26, Chapter 3, Proposed Plan, Transportation, Transportation Operations: TRAN (D). We request the plan retain "*adequate and feasible access for economic and other purposes*" as it is the correct standard used for inholdings "effectively surrounded" by conservation system units (i.e. designated wilderness) in ANILCA section 1110(b). "Reasonable access" is the standard in ANILCA section 1323, which applies to general national forest lands, not designated wilderness.

Page 3-107, Proposed Plan: We do not support this management prescription, which would recommend FERC not authorize hydroelectric facilities on rivers found eligible and suitable for inclusion in the Wild and Scenic River System in the 1997 Tongass Land Management Plan. This comment also applies to other management prescriptions found elsewhere in the plan that rely on the 1997 wild and scenic river recommendations as their basis. See above general comment on wild and scenic rivers.

Page 4-10, Chapter 4, Proposed Plan: Fish Habitat Planning, Fish Habitat and Channel Processes, part 3: ANILCA section 1326(b) expressly prohibits further studies for the single purpose of considering the establishment of a conservation system unit, which includes Wild and

Scenic Rivers, unless authorized by ANILCA or a further act of Congress. Consideration of new wilderness or wild and scenic rivers in this context is inappropriate and we request the following revision:

> *Consider topics such as erosion processes, watershed hydrology, vegetation, stream channel morphology, water quality, ~~wilderness designation, recommendations for inclusion into the Wild and Scenic River System~~, species and habitats, and human uses, during analyses.*

Page 4-31, Proposed Plan: III. Temporary Facilities. ANILCA section 1316 applies to all federal public lands where the taking of fish and wildlife is authorized but it does not differentiate between subsistence and non-subsistence use. We request the Service consider whether the distinction in this section is necessary or appropriate.

Page 4-44, Proposed Plan: Chapter 4 Recreation Resource Planning: The following guideline appears to be relevant to ensuring safe access to communities and popular recreation areas. It is unclear why it is being removed. We request the Service re-consider and provide rationale if it is not retained in the final plan.

> *Support a system of anchorages suitable for recreation boats along small boat waterways that connect communities or provide access to popular recreation attractions.*

Page 3-382, third paragraph, DEIS: We request the following edit for clarity and consistency with ANILCA sections 802 and 804:

> *It also states, in part, that ~~"customary and traditional"~~ subsistence uses of renewable resources "shall be the priority consumptive uses of all such resources on the public lands of Alaska <u>when it is necessary to restrict take</u>."*

Page 3-382, fourth paragraph, DEIS: We request the following edit for accuracy:

> *This ruling took the state out of compliance with ANILCA and the federal government has managed <u>harvest of</u> subsistence resource s <u>under federal subsistence regulations</u> on federal lands in Alaska since 1990. As a result, <u>federal</u> subsistence harvests of fish and wildlife on the Tongass National Forest are presently managed by the Forest Service (Schroeder and Mazza 2005).*

ENVIRONMENTAL CONSERVATION[6]

The Alaska Department of Environmental Conservation (ADEC) provided the following comments on the DEIS.

Page 3-16, paragraph three, sentence one, should read: "*The State of Alaska Department of Environmental Conservation (ADEC) under the Clean Air Act (CAA), via Title I and Title 5 of the EPA approved State Implementation Plan (SIP) regulates air emissions from stationary sources.*"

Page 3-18, paragraph three, sentence seven, notes that " *In an effort to better address the air quality concerns in the Wilderness, the Forest Service and ADEC enters into a Memorandum of Understanding each year to train Forest Service wilderness rangers to visually monitor cruise ship emissions with EPA-approved standards*." This sentence should be updated to reflect that the MOU is static and does not get entered into each year.

Page 3-19 paragraph one, sentence three, should read: "*EPA and ADEC have **limited** regulatory responsibility, under the Clean Air Act, for air quality related to these kind of sources*." This sentence was discussing indirect sources such as firewood burning and vehicle emissions.

Page 3-22, paragraph two, sentence five refers to "shrinking alpine habitats". This may need to be reexamined and perhaps changed to read "**changing** alpine habitats" to reflect the fact that glacier melting may expose new alpine habitat at a quicker rate than those of altitudinal forest shifts.

Page 3-56, paragraph three, sentence two should read: "*Turbidity criteria indicate values will not exceed 5 nephelometric turbidity unites (NTUs) over natural conditions, when **natural** values are less than 50 NTUs*." The original text used the word "nature".

Page 3-68, paragraph five, sentence two should read: "*Landslide debris (e.g., sediment, large wood) that enters the stream may block or shift channels, fill pools, and **increase the presence of fine sediments** in the channel network*." The original text used the words "*increases fines presences*" which is grammatically cumbersome.

Appendix G, page G-11, M4(c) should be revised to read "*Measurements required by M4; a and b are from MHW (Mean High Water) to depths of **100** feet MLLW (Mean Lower Low Water).*"

[6] The State of Alaska's primary contact for DEIS comments related to environmental conservation is Gary Mendivil of the Alaska Department of Environmental Conservation. He can be reached at gary.mendivil@alaska.gov or 907-465-5061.

MISCELLANEOUS EDITS

Typos

- Draft EIS, Page A-1: An incorrect date of "June 23, 2016" is given for publishing the corrected Notice of Intent.

- Draft EIS, Page B-18: "Intermeidate" is misspelled.

ATTACHMENT

The Working Forest Group (TWFG) report, *Strategies to Maintain a Viable Timber Industry in Southeast Alaska, 2015.*

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Strategies to Maintain a Viable Timber Industry in Southeast Alaska

January 2015

Prepared for:
USDA, Forest Service, Alaska Region
Under Challenge Cost-Share Agreement (14-CS-11100500-020)

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EXECUTIVE SUMMARY

The purpose of this Challenge Cost-Share Agreement was for The Working Forest Group (TWFG) to facilitate an analysis that defined where and what types of investments should be made in retooling the existing old growth timber industry into one that is dependent on young growth timber supply from Southeast Alaska considering all lands as sources.

Originally, the project scope called for facilitation of a 2-day work session to collect the information from 15 knowledgeable individuals from various Southeast Alaska timber industry segments (manufacturing/processing, harvesting, land owner/operator, logistics, road building, consulting, and other). After several attempts to reach a cross-section of the industry by telephone and email, several respondents emphasized a frustration with the process. The current industry has been involved in discussions for several years and have not seen their primary concern for timber supply being addressed. This non-participation led to a request that the project scope be adjusted from a two-day work session to on-site discussions with industry at their various mill sites. The U.S. Forest Service agreed to amend the scope and on-site interviews were conducted in November 2014.

The common message TWFG heard from those interviewed was that the timber industry in Southeast Alaska will cease to exist unless there is old growth timber made available while the young growth matures and/or a market for Alaska's young growth is developed.

Therefore, based on the information provided on the surveys and during the interview process along with The Working Forest Group's knowledge of the timber industry, TWFG would like to propose two potential future industry concepts:

- Future Industry Concept #1: The creation of a viable timber Industry in Southeast Alaska that is dependent on young growth fiber, can only be achieved by extending the rotation length until young growth trees develop old growth characteristics. Old growth harvest on the Tongass National Forest must continue for the foreseeable future.

- Future Industry Concept #2: The creation of a viable timber Industry in Southeast Alaska that is dependent on young growth fiber, which maintains the existing industry while ceasing the harvest of old growth timber stands on the Tongass National Forest within five (5) years.

With the cornerstones for future forest management in Southeast Alaska being based on:

- Active Forest Management by use of the abundant forest resources of the region,
- Making Southeast Alaska investment friendly to future timber industry investors,
- Developing an all Landowners (public and private) Management Strategy based on the Working Circle concept; and
- Using Timber Management to develop methods to resolve the regional issues of:

    - ✓ Transportation
    - ✓ Renewable Energy
    - ✓ Solid Waste
    - ✓ Employment – development and retention of tomorrow's workforce

INTRODUCTION

Background

At the request of the U.S. Department of Agriculture, Forest Service, Alaska Region (USFS), The Working Forest Group (TWFG) was granted funds under a Challenge Cost-Share Agreement (14-CS-11100500-020) to complete an analysis that defines where and what types of investments should be made in retooling the exiting old growth timber industry into one that is dependent on young growth supply from Southeast Alaska considering all lands as sources.

The United States Department of Agriculture, Office of the Secretary issued *Secretary's Memorandum 1044-009 – Addressing Sustainable Forestry in Southeast Alaska* on July 2, 2013 (Appendix A) stating that the USDA Forest Service must speed the transition away from old growth timber harvesting, towards a forest industry that utilizes young growth and calling for additional research to develop effective ways to meet the challenges of the transition over the next 10-15 years. Hence, the support for this report.

This analysis was to be conducted by facilitating a 2-day work session with 15 individuals, who were chosen from surveys created and distributed by The Working Forest Group (TWFG), based on the respondent's interest in attending the work session and their knowledge of the Southeast Alaska timber industry. However, the original project scope was modified from facilitating a 2-day work session to one-on-one meetings to better fit the industry's work season.

Report Objective

The objective of this report is to deliver the following timeframe information for a transition from old growth to young growth:

- ✓ Short-Term (Present Day to Five Years)
- ✓ Mid-Term (Six Year to Fifteen Years)
- ✓ Long-Term (Beyond Fifteen Years)

REPORT DATA COLLECTION / WORK SESSION / INTERVIEWS

Objective

In order to gain insight into where and what types of investments should made in retooling the existing old growth timber industry into one that is dependent on young-growth, the original project scope was to select and recruit 15 representatives from the forest industry and forest land owners within Southeast Alaska to attend a two-day work session in Ketchikan.

Survey Planning and Methodology

The process was to:

1. Build a list of potential participants
2. Construct a short survey (Appendix B) to compile preparatory information to schedule a two-day work session and assess participation level interest
3. Distribute survey and response through The Working Forest Group via web, email, and mail
4. Retrieve, compile, and summarize data
5. Select and invite participants to a two-day work session
6. Conduct work session
7. Compile information from all data received and build a report
8. Deliver the draft and review with client
9. Deliver final report and recommendations

The data collection of the project started in April 2014 with the development of The Working Forest Group website (www.akworkingforest.org) in order to distribute, collect and compile the survey information. Concurrently, a list of 100 potential participants was built with the help of the State of Alaska Department of Commerce and Economic Development, the Division of Forestry, other forest industry contacts, and by searching the State of Alaska business license database.

A short, but concise survey was developed (Appendix B) asking questions such as: contact information, the respondents industry, number of years involved in the business, number of employees, and their business plan for the next ten years. Additional questions asked their views on: 1) what would make a viable forest products industry in Southeast Alaska; 2) did they think the government (federal, state, local) should make investments to advance the transition to young growth and if so, what area (multiple choice); 3) volume of economically viable young growth manufacturing/processing opportunities they saw (multiple choice); 4) activities/components they considered essential for an integrated young growth forest products industry (multiple choice); 5) could their business operate exclusively from a young growth resource today (yes/no), and if not, what changes would need to be made to their business (multiple choice); and 6) landowners were asked if they were committed to keeping their entire managed forest land base in production for the next rotation or harvest (yes/no) and if not, why. The survey concluded with questions related to the proposed 2-day work session - if they were interested in participating, and if so what dates and would they need financial assistance to attend.

Initial contact was made with 47 businesses and individuals (Appendix C) with ties to the Southeast Alaska forest products industry via email on July 10, 2014. The email included an introduction to the project, the proposed 2-day work session, and The Working Forest Group (TWFG). The ten question survey was attached as a fillable PDF form, but a direct link was given to where the survey could be taken online and submitted as well as instructions on how to fill the survey out offline and then be able to mail, fax, or email. The email was then followed-up by phone calls the week of July 14, 2014 with the addition of another seven to ten contacts who did not have email addresses.

From this initial outreach only eight accepted the invitation to complete the survey. The method above was repeated on July 31, 2014 with three additional surveys completed. Survey responses can be found in the Results section below.

Survey Implementation Issues and Revised Project Scope

Out of the eleven responses received, only five showed interested in attending a 2-day work session. Feedback received outside the survey responses were: 1) it was the wrong time of year to try and hold a 2-day work session due to the industry's work season and 2) the current industry has been involved in discussions for several years and have not seen their primary concern for timber supply being addressed and did not see the value in participating in another work session.

In early September 2014 TWFG pulled together a list of 15 potential work session attendees based on their forest industry affiliation and industry knowledge, including those who showed interest from the survey. An invitation was sent to the work session invitees on September 17, 2014 with only one individual accepting the invitation.

Revised Project Implementation

Therefore, TWFG decided that the 2-day work session was not the most productive way to collect the information and revised the project scope by trying to schedule and meet people individually during the Alaska Forest Association's 57th Annual Convention in Anchorage (October 22-24, 2014), at the Forest Products Task Force meeting in Klawock (November 17, 2014), and by on-site visits (Prince of Wales Island and Ketchikan, November 16-19, 2014) instead of facilitating a formal 2-day meeting.

From October 22-November 19, 2014 TWFG spoke personally to 18 individuals tied to the Southeast Alaska timber industry (land owner-2; timber consulting-2; manufacturing/processing-9; harvesting-3; other-2.)

Results

The purpose of the one-on-one meetings was to collect each person's thoughts on how and what they saw was needed in order to transition from an old growth industry to a young growth industry. The common message that TWFG heard from respondents (17 out of 18) was:

- the current young growth timber is too young to be economically harvested and there is no current product/market for the timber; and
- if there is not some volume of old growth made available while the young growth matures, they will no longer be in business.

Only one manufacturer saw a potential for young growth and that potential was in a pellet/chip manufacturing facility.

Survey Responses

Survey Responses – Page 1 of 3

#	City	State	1. What segment of the Forest Products Industry are you currently active in? Select All That Apply	2. How many years have you been operating a business and/or been involved in the forest Products industry in Southeast Alaska?	How many employees?	3. Which condition best describes your plan for 10+ years?	4. What do you think makes a viable forest products industry in Southeast Alaska?
1	Craig	AK	Harvesting	7	21+	Will operate until I retire and shut down	Keeping timber sales active
2	Petersburg	AK	Road Building	33	11-15	Already have a successor in place	Available timber
3	Ketchikan	AK	Manufacturing/Processing; Harvesting; Logistics; Land Owner/Operator	36	21+	Will or are seeking successor depth now	Adequate, affordable timber supply and reasonable regulatory requirements
4	Ketchikan	AK	Harvesting; Logistics; Land Owner/Operator; Marketing	24	21+	Unknown with current industry	An industry with stable customers and supply that is economically viable. To a scale that makes the industry cost competitive with world markets.
5	Wrangell	AK	Timber Consulting - Viking Lumber & others	49	1-5	Will operate until I retire and shut down	Only 1 medium and a few small sawmills left - need a couple more medium sawmills to keep infrastructure and to transition into a second growth industry. Old growth needed for another 10-15 years until second growth is viable - work during this time to get timber sales to attract timber industry - not enough acres right now
6	Ketchikan	AK	Manufacturing/Processing	12	1-5	Will operate until I retire and shut down	A stratisfied manufacturing industry will take substantial private investment and a marketing program to differentiate longass species and characterstics in the market place
7	Juneau	AK	forestry consulting	37	1-5	Already have a successor in place	A harvest volume exceeding 300 million bf of old growth and second growth until a volume of second growth can supply most all of this volume. This includes an industrial capacity that exceeds 230 bf of net log scale and does not include the addition of wood that could be converted into biofuels as demand ramps up. This means that just about all of the existing second growth, regardless of the land classification that it is located on, must be included as committed to management for harvest. Second growth that is denied such supply needs to be exchanged with additional old growth on an acre for acre basis because future rotations will need that amount of land to maintain such a volume into perpetuity. There should be mills of sufficient scale to efficiently use the wood so that the manufactured product can compete. These mills should be well located to benefit small and large communities including POW road system, Mitkof/Kupreanof, Hoonah
8	Thorne Bay	AK	Manufacturing/Processing; Harvesting	20		Will or are seeking successor depth now	Jobs with experienced personal, stable timber supply, so we can have efficient equipment
9	Ketchikan	AK	Land Owner/Operator	8	21+	Will or are seeking successor depth now	Sustainable and predictable timber volume into supply chain that attracts and promotes investment in technology and value add activities
10	Ketchikan	AK	Land Owner/Operator	36		Will operate until I retire and shut down	
11	Ketchikan	AK	Harvesting	32		Will operate until I retire and shut down	Timber supply that is economic

Continued

Survey Responses – Page 2 of 3

#	5. Do you think federal, state, or local government should make investments in Southeast Alaska to advance the transition to young growth in the Forest Products industry?	If YES, what area would you prefer that investment take place? Select One	6. Do you think young growth manufacturing/processing opportunities would be economically viable in Southeast Alaska at ... Select One	7. Which of the following activities/components would you consider essential for an integrated young growth Forest Products Industry in Southeast Alaska? Select All That Apply	8. Would your current business be able to operate exclusively from a young growth resource today?	If NO, what changes would you need to make to your business? Select All That Apply
1	No		less than 50 MMBF	Log Exporting	No	Equipment; Products/Services
2	Yes	Harvesting Equipment Incentives	101-200 MMBF	Harvesting; Sawmill; Value Added Remanufacturing; Residual Product Uses, i.e. Energy, Pulp, OSB, MDF; Engineered Wood Product LVL/PLGW	No	Equipment; Workforce Skill Set
3	No		101-200 MMBF	Harvesting; Sawmill; Residual Product Uses, i.e. Energy, Pulp, OSB, MDF; Engineered Wood Product LVL/PLGW; Log Exporting	No	Equipment; Workforce Skill Set; Products/Services; Adequate, affordable timber supply
4	No		101-200 MMBF	Harvesting; Residual Product Uses, i.e. Energy, Pulp, OSB, MDF; Log Exporting; Local niche products	Yes	
5	Yes	More of the TNF needs be in control under state or private ownership - instead of providing grants, which means the industry isn't viable - federal just can't sell timber - expanding state forest makes sense!	101-200 MMBF	Harvesting; Sawmill; Value Added Remanufacturing; Residual Product Uses, i.e. Energy, Pulp, OSB, MDF; Engineered Wood Product LVL/PLGW; Log Exporting	Yes	
6	No		101-200 MMBF	all of the above	No	Old growth is our business
7	Yes	Make financing such as guaranteed loans re???	101-200 MMBF	Harvesting; Sawmill; Value Added Remanufacturing; Residual Product Uses, i.e. Energy, Pulp, OSB, MDF; Engineered Wood Product LVL/PLGW; Log Exporting	Yes	
8	No		101-200 MMBF	Residual Product Uses, i.e. Energy, Pulp, OSB, MDF; Log Exporting	No	Markets/Customers
9	Yes	Forest Infrastructure (roads, ports, training, etc.)		Harvesting; Log Exporting	Yes	
10	Yes	Forest Infrastructure (roads, ports, training, etc.)		Harvesting; Residual Product Uses, i.e. Energy, Pulp, OSB, MDF; Log Exporting	Yes	
11	No, nothing cost effective the government can do. It's a matter of time - wait for the timber to grow		Depends on markets & location & economic layout	Harvesting, sawmill, log exporting	Have been doing it for 2 years. However, not enough larger 2nd growth stands to keep us busy. Too soon for 2nd growth in the Tongass	

Continued

Survey Responses – Page 3 of 3

#	9. LANDOWNERS ONLY: Are you committed to keeping your entire managed forest land base in production for the next rotation or harvest?	If NO, please explain:	10. If The Working Forest Group (TWFG) proceeds with a 2-day work session in Ketchikan, would you be interested in participating*?	Week Choice #1 Sept-Oct 2014?	Week Choice #2 Sept-Oct 2014?	Would you need financial assistance in order to attend?	Additional Comments (optional)
1			No				
2			No				No one is available to discuss attending a work session at this time. So, I cannot answer this last question. Everyone is out working on jobs, I would think if you have a work session, the later in the year the better, when our seasonal work is completed for the year.
3			Yes			No	I don't agree with question #6 because I believe that a viable manufacturing industry will require 300+ mmbf. An export only industry could survive at the lower volumes if the harvest costs were reasonable.
4			Yes			No	
5			Yes			Yes	
6			Yes			No	If the forest working group is just a group to rubber stamp a young growth agenda, you don't need us. I don't think it is a good idea, If you want to discuss how we can better process all wood in the region then I'm interested. Currently we have a round log export industry with very little manufacturing.
7			No				Notice dates are too short. Would not need financial assistance to attend. I am pretty much retired, but have participated in the industry in the lower 48 and here since 1954.
8			No				the second growth isnt' ready all the small log hemlock oldgrwth is being exported why becaus you can't compete with lower 48, shipping is a challange at $150 per m from pow to sea do the no's i would like to see them and what the profit would be. Pow biofuels has a plan with the 2nd growth and could use it all but we need pellet boilers put in SE and to build a pellet plant to feed the boilers POW biofuels has a plant designed and the busness plan is finished we have 20 acers for this plant.
9	Yes		Yes			No	
10	Yes		Yes			No	Old Growth timber volume should be considered as part of a future industry. There are several existing operators (shake and shingle mills, music wood producers) that will not be able to continue to operate w/o OG volume.
11							

Other comments heard from in-person interviews were:

- The current young growth needs 180+ years of growth to be viable.
- Still need 75-120 MMBF of old growth in order to stay in business while current young growth matures.
- Old growth products is Alaska's only viable timber market at this time because there is no other old growth supplier.
- Alaska's young growth cannot compete in the market because of high shipping costs to Seattle.
- Pulp mills could/would be the biggest consumer of Alaska's current young growth, however no more pulp mills in Alaska.
- There is potential for a whole log, young growth export to Asia, but not dimensional lumber. This does not help current small operators since most focus on dimensional lumber and old growth specialty products – this does not allow the industry to grow.
- Currently, there isn't enough infrastructure by the way of trucks to haul logs or cheap power to transition to a large enough young growth industry to be sustainable.
- Alaska's young growth cannot compete with Washington.
- A 10% profit will not bring investors to Alaska.
- Alaska has the best old growth hemlock, vertical grain wood in the world that is used for doors, windows, and molding. Young growth does not act the same, it's too crooked.
- Initially Alaska's old growth cedar did not fit in the market, but now it's in demand for high end garage doors, entry doors, decks, and stairs and goes for a premium price. Young growth cedar is for lower end commodities such as fencing because it's crooked and splits easily.
- The only other comparable cedar on the market as compared to Alaska's old growth cedar is British Columbia cedar.
- Alaska's old growth spruce is a wanted commodity in Japan, Indonesia, and China (70%) and the other 30% goes to Tacoma for Steinway pianos in New York and Germany.
- In order to keep a timber industry in Alaska there needs to be a mix of old growth timber (spruce, hemlock and cedar) made available as the young growth matures and/or a market for young growth is developed.

The straightforward message TWFG heard from those interviewed was that there will be no timber industry in Southeast Alaska unless the majority of the timber offered is old growth, while the young growth matures and/or a market for Alaska's young growth is developed.

Based on the information provided during the interview process and with The Working Forest Group's working knowledge of the timber industry TWFG would like to propose two potential future industry concepts, both with recommendations and the Future Industry Concept #2 broken into three (3) timeframe analyses: 1) Short-term defined as present day to five (5) years out; 2) Mid-term defined as year six (6) to fifteen (15) years out; and 3) Long-term as defined beyond fifteen (15) years out.

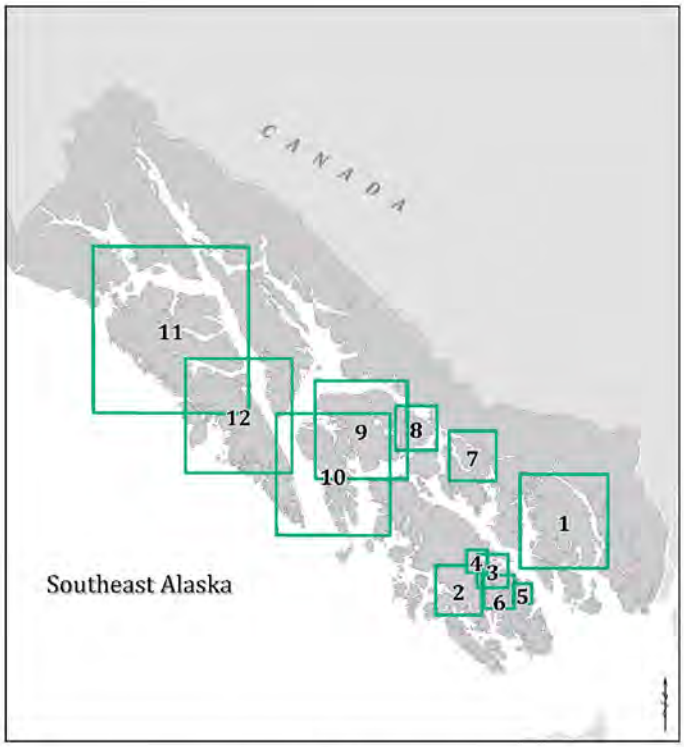
SOUTHEAST ALASKA'S FUTURE TIMBER INDUSTRY

The cornerstones for future forest management in Southeast Alaska will need to be based on:

- Active Forest Management by use of the abundant forest resources of the region,
- Making Southeast Alaska investment friendly to future timber industry investors,
- Developing an all Landowners (public and private) Management Strategy based on the Working Circle Concept; and
- Using Timber Management to develop methods to resolve the regional issues of:

  - ✓ Transportation
  - ✓ Renewable Energy
  - ✓ Solid Waste
  - ✓ Employment – development and retention of tomorrow's workforce

Infrastructure Needs maps have been created for 12 regions as seen below in the index of maps. Each map can be found in Appendix G and will be referenced in the Future Industry Concept #1 and #2 sections.



Infrastructure Needs
Map Index

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11 - Chichagof Island
12 - Baranof Island

Map Developed by Alaska Mental Health Trust Land Office

Future Industry Concept #1

Creation of a viable timber Industry in Southeast Alaska, dependent on young growth fiber, can only be achieved by extending the rotation length until young growth trees develop old growth characteristics. Old growth harvest on the Tongass National Forest must continue for the foreseeable future.

Basis for Concept #1

The existing timber industry in Southeast Alaska, both exporters and manufacturers, believe that the harvest of old growth timber must occur in order to maintain a viable industry into the future. The only Southeast Alaska landowner currently able to provide sufficient quantities of old growth to maintain a viable industry is the U.S. Forest Service.

Exporters and manufacturers differ regarding the management of young growth stands. Round log exporters maintain that young growth can and should be included in the current Tongass Timber Program and are considered that young growth trees may reach a diameter size that makes them undesirable on the international market.

Manufacturers believe that all young growth stands should be allowed to grow over an extended rotation period, usually estimated to be between 200-250 years until the trees develop sufficient fiber containing old growth characteristics that such fiber meets niche market requirements. For a current young growth stand to have enough time to grow shop grade or better wood requires the continued cutting of old growth for at least another 150 years.

There is limited demand for Sitka spruce as a species to be manufactured into dimensional lumber. Current dimensional lumber producers/marketers include small percentages of Sitka spruce into lumber orders as “other species” or incidental and limited to no more than 5% of the volume. Hemlock, pine and fir are the most common species used on the West Coast for dimensional lumber. Existing manufacturers are not optimistic about being able to integrate large volumes of Sitka spruce into current markets. Based on the Species Summary Report provided by the USFS (Appendix D) older stands (45-65 years of age) of young growth on the Tongass National Forest are predominately hemlock by the number of stems per acre, but volume per acre is dominated by Sitka spruce. It is not uncommon to have spruce make up two thirds of the volume in a stand.

Recommendations

1. To maintain an old growth industry for a minimum of 150 years from today, the U.S. Forest Service needs to develop a timber sale program that will provide on an annual basis, a minimum sufficient volume to meet the statutory requirements of Tongass Timber Reform Act (TTRA) Sec. 101 (Appendix E) and ANILCA Section 705(a) (Appendix F); that *“the Secretary shall”* provide a supply of timber from the Tongass National Forest which meets the annual market demand and the market demand for each planning cycle.

2. Current and future forest plans development land use designations must provide sufficient acres of forested lands to meet the supply demand of ANILCA and TTRA (Recommendation 1) while, *"providing for the multiple use and sustained yield of all renewable resources" (*TTRA Sec. 101).

3. The Tongass Exemption to the Roadless Rule must be re-instated.

4. Develop long term "Agreements" between Federal, State and Private Landowners addressing:

    a) Access and Road Use – This agreement should provide all landowners the ability to use each other's infrastructure at no cost to the non-landowner. Such an agreement should include a project specific use agreement that can be implemented quickly under the umbrella agreement.

    b) Infrastructure – Develop collaboratively with an emphasis on consolidating existing infrastructure and minimizing future development.

    c) Maintenance – Ensure that maintenance and upgrades of infrastructure is performed by or paid for by the "user" and includes activities needed to "maintain" permits as well.

5. Develop and implement an Infrastructure Improvement Plan for roads, sort yards, log transfer facilities, rafting grounds, long/short term storage areas and barge/ship loading facilities on all ownerships. Consolidate existing road systems to maximize volume at centralized sort yards, log transfer facilities and ship loading points. Road systems for resource management should be connected to existing community road systems when possible to reduce management costs and expand local workforce job opportunities.

    a) Consider at the minimum the following development needs:

        - **Revillagigedo Island:** Connect all isolated road systems; develop a centralized wood processing facility (Leask Cove) including a sort yard, log transfer facility and barge/ship loading facility. Consider development of an industrial park that includes a sawmill, and a wood-energy / municipal solid waste fueled electrical plant. (Map can be found in Appendix G – Map 1.)

        - **Prince of Wales Island – Trocadero Bay:** Connect the private road systems in Trocadero Bay to the Hydaburg Highway (Map can be found in Appendix G – Map 2.)

        - **Prince of Wales Island – Cabin Creek:** Provide access to the Prince of Wales road system by connecting the private road systems at Kina Cove, Cabin Creek, Paul's Bight and Smith Lagoon with the USFS roads at Polk Inlet and Little Coal Bay (Map can be found in Appendix G – Map 3.)

- **Prince of Wales Island – Sandy Point:** Connect the private roads at Sandy Point road to the Hollis Highway (Map can be found in Appendix G – Map 4.)

- **Prince of Wales Island – Dolomi Bay:** Connect the Dolomite, Lancaster Cove, Reid Cove and Dora Bay road systems together. Look at feasibility of a connection with the West Arm of Cholmondeley Sound road system (Map can be found in Appendix G – Map 5.)

- **Prince of Wales Island - West Arm of Cholmondeley Sound:** Connect the West Arm of Cholmondeley Sound with Sulzer Portage (Map can be found in Appendix G – Map 6.)

- **Wrangell Island:** Extend the existing Wrangell Island road system to Fool's Inlet. At Fool's Inlet construct a sort yard, log transfer facility and a barge/ship loading facility (Map can be found in Appendix G – Map 7.)

- **Mitkof Island:** Blind Slough development to include improvements to existing log transfer facility, construction of a sort yard and barge/ship loading facility (Map can be found in Appendix G – Map 8.)

- **Kupreanof Island:** Improve or construct sort yards, log transfer facilities, and barge/ship loading facilities at both Kake and Totem Bay. Connect the Portage Bay road system with Kake road system. Extend Kake road system south to Totem Bay (Map can be found in Appendix G – Map 9.)

- **Kuiu Island:** Connect the existing road system to No Name Bay, with development in No Name Bay to include a sort yard, log transfer facility, and a barge/ship loading facility. Saginaw Bay development to include a sort yard and log transfer facility. (Map can be found in Appendix G – Map 10.)

- **Chichagof Island:** Connect the road systems of False Island to Corner Bay, Hoonah to Salt Lake Bay, Hoonah to Freshwater Bay, Salt Lake Bay to Eight Fathom Bight (if possible), and Port Fredrick to Sealaska land (if possible). Hoonah development to include a sort yard, log transfer facility, and a barge/ship loading facility. (Map can be found in Appendix G – Map 11.)

- **Baranof Island:** Connect the road systems at Rodman Bay, Fish Bay and Katlian Bay to the community of Sitka. Develop a sort yard, log transfer facility and barge/ship loading facility at Sitka. Consider connecting, if possible, the Northern Baranof Island road systems at Appleton Cove, Saook Cove and Hanus Bay with the Rodman Bay Road system. (Map can be found in Appendix G – Map 12.)

Future Industry Concept #2

Creation of a viable timber Industry in Southeast Alaska, dependent on young growth fiber, which maintains the existing industry while ceasing the harvest of old growth timber stands on the Tongass National Forest within five (5) years.

Basis for Concept #2

The Working Forest Group proposes that the Tongass National Forest implement the following recommendations to meet the mandates listed below from the Secretary's Memorandum 1044-009, dated July 2, 2013 (Appendix A):

> *to speed the transition away from old growth timber harvesting and towards a forest industry that utilizes second growth – or young growth – forests.*
>
> *to effectuate this transition over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth.*
>
> *to retain the expertise and infrastructure of the existing industry so businesses can quickly re-tool.*

Recommendations

✓ Short-Term (Present Day to Five Years)

1. USFS provide the existing industry old growth volume based on the Tongass Integrated Plan (TIP) (http://www.fs.usda.gov/detail/tongass/landmanagement/?cid=stelprd3812864 – USDA Forest Service) for the next five (5) years. The majority of the volume sold would be old growth, with only incidental volumes of young growth sold as a by-product of wildlife habitat development in non-development lands.

2. Develop long term "Agreements" between Federal, State and Private Landowners addressing:

    a) Access and Road Use – this agreement should provide all landowners the ability to use each other's infrastructure at no cost to the non-landowner. Such an agreement should include a project specific use agreement that can be implemented quickly under the umbrella agreement.

    b) Infrastructure – Develop collaboratively with an emphasis on consolidating existing infrastructure and minimizing future development.

    c) Maintenance – Ensure that maintenance and upgrades of infrastructure is performed by or pay for by the "user". Include activities needed to "maintain" permits as well.

3. Conduct Stand Surveys of all young growth stands on all land-ownerships and gather at a minimum the following data:

    - Acreage – available over multiple rotations for timber production
    - Stand Age at the time of the survey
    - Species Composition
    - Site Index including information on aspect, slope and elevation for each stand
    - Management intent of the owner – will the stand be intensely managed over a short rotation or will rotation be extended to accomplish landowners' management goals.

4. Develop an Infrastructure Improvement Plan for roads, sort yards, log transfer facilities, rafting grounds, long/short term storage areas and barge/ship loading facilities on all ownerships. Consolidate existing road systems to maximize volume at centralized sort yard, log transfer facilities and ship loading points. Road systems for resource management should be connected to existing community road systems when possible to reduce management cost and expand local workforce job opportunities.

    b) Consider at the minimum the following development needs:

    - **Revillagigedo Island:** Connect all isolated road systems; develop a centralized wood processing facility (Leask Cove) including a sort yard, log transfer facility and barge/ship loading facility. Consider development of an industrial park that includes a sawmill, and a wood-energy / municipal solid waste fueled electrical plant. (Map can be found in Appendix G – Map 1.)

    - **Prince of Wales Island – Trocadero Bay:** Connect the private road systems in Trocadero Bay to the Hydaburg Highway (Map can be found in Appendix G – Map 2.)

    - **Prince of Wales Island – Cabin Creek:** Provide access to the Prince of Wales road system by connecting the private road systems at Kina Cove, Cabin Creek, Paul's Bight and Smith Lagoon with the USFS roads at Polk Inlet and Little Coal Bay (Map can be found in Appendix G – Map 3.)

    - **Prince of Wales Island – Sandy Point:** Connect the private roads at Sandy Point road to the Hollis Highway (Map can be found in Appendix G – Map 4.)

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5. Land Exchange between the U.S. Forest Service and the State of Alaska - the National Forests within the State of Alaska are in the process of writing a new forest plan (Chugach) or amending an existing plan (Tongass). Both forests have State lands within or adjacent to their external boundaries. The Alaska Timber Jobs Task Force report of June 2012 (Appendix H) contains the recommendation to exchange 250,000 acres (recommendation #4 of Section 2, Task 5). This recommendation was driven in part by the Chugach National Forest's interest in obtaining state owned lands within or near the Chugach for recreational purposes.

Consideration should be given to a land exchange between the State and the U.S. Forest Service. Such an exchange would maintain the existing amount of land by ownership (no net loss of national forest lands or state lands) and would help align ownership with land use objectives. State land within or near the Chugach National Forest could be exchanged for lands within the Tongass National Forest. Federal lands transferred to the State should be included in the Southeast State Forest.

At the conclusion of the land exchange (5 years from now) the Tongass timber sale program would cease selling old growth timber except for volumes affected by large insect or disease outbreaks, catastrophic windthrow events, the salvage of dead or down material and incidental volumes sold through a micro-sale program (sales under 50 MBF). Lands transferred from the State to the USFS could be developed for non-timber purposes (recreation facilities), but would be excluded from availability for timber harvest.

✓ Mid-Term (Six Years to Fifteen Years)

1. Implement Land Exchange between USFS and State of at least 250,000 acres or per the recommendation of the Alaska Timber Jobs Task Force report.

2. Implement Infrastructure Plan

3. Continue collecting young growth stand data on all lands

4. USFS Timber Sale Program will only include of the harvest of old growth timber volumes affected by large scale insect and/or disease outbreaks, catastrophic windthrow events, the salvage of dead or down material and incidental volumes sold through a micro-sale program (sales under 50 MBF). Stewardship contracting should be used as the contracting method on all sales.

   Young growth volumes sold during this timeframe would be minimal and be a by-product of treating young growth acreage in non-development land use designations for purposes of wildlife habitat development.

5. Develop a young growth management/marketing strategy in association with the State and private landowners by coordinating the harvest between land ownerships based on young growth stand data gathered in the short and mid-term and future land management plans by land ownership should be consider when developing harvest plans.

   Also, consider the Working Circle concept that proposes the establishment of five (5), 50-mile radius Working Circles centered in the Southeast Alaska communities of Hoonah, Kake, Wrangell, Klawock, and Ketchikan. The total operating area of these Working Circle centers encompasses more than 95 percent of the production forest land use designations (LUDs) contained within

the Tongass National Forest (TWFG. pg. 15). The primary goal of the Working Circle concept, within the TWFG paper cited, was the creation of an appraisal point at each of the five (5) Working Circle centers to generate positive value USFS timber sales. When included as part of this report's Infrastructure Development Plan, the Working Circle concept maximizes future volume across all landownerships at centralized locations that will provide an economy of scale and manufacturing opportunities.

Research and/or consider potential young growth product development such as:

a) Pacific Rim needs and cutting methods/dimensions – Southeast Alaska has a competitive advantage over the Pacific Northwest in shipping cost to Pacific Rim countries; can that advantage be used by mills to provide manufactured products to Pacific Rim countries? What are those products?

b) Bio-diesel for marine use – Navy, Coast Guard, Cruise ships, commercial fishing fleet – can waste material and/or non-traditional commercial wood fiber associated with timber harvest be used to produce bio-diesel? Is there a competitive advantage to produce that fuel in Southeast Alaska in connection with the supposed "boom" that will occur in the Arctic? Can such a product be integrated into the marine support industry currently being envisioned for Southeast Alaska?

c) Stock for remanufacturing – veneer, timbers, and shop material – can primary manufacturing work to supply stock to the Pacific Rim or other international markets vs. domestic markets? Is supplying domestic markets economically feasible?

d) Wood energy – producing fuel products for export outside the region and/or producing heat and power within the region. Is it better to produce power at a small scale locally or at a larger "regional size" and transport via a region grid? Can waste material and/or non-traditional commercial wood fiber associated with timber harvest be combined with municipal solid waste to produce power and resolve communities' issues with handling solid waste?

6. Develop a mill infrastructure/transition plan in association w/ State and private landowners based on the developed young growth management and marketing strategy as proposed above. What is the infrastructure need based on the strategies developed? What is the infrastructure needs based on the annual available volume from the "all lands" management strategy? Is it one or two large capacity mills that consume the volume generated on an annual basis region wide? Or multiple high efficiency mills strategically located across the region (Working Circle concept)? What infrastructure is needed to produce primary manufactured products vs. finished products?

Are there different infrastructure needs when considering the production of domestic vs. international products?

✓ Long-Term (Beyond Fifteen Years)

1. Seek investors and entrepreneurs to implement plans and strategies developed during the mid-term.

2. USFS starts offering young growth volumes from National Forest lands when available volumes combined with volume from all other landowners are sufficient on an annual basis to provide for the future industry as envisioned and planned for during the mid-term.

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APPENDIX H: ALASKA TIMBER JOBS TASK FORCE (SHORT REPORT) – JULY 2012

APPENDIX A: SECRETARY'S TRANSITION MEMORANDUM JULY 2, 2013

UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

July 2, 2013

SECRETARY'S MEMORANDUM 1044-009
Addressing Sustainable Forestry in Southeast Alaska

I. PURPOSE AND BACKGROUND

Alaska's Tongass National Forest is a national treasure. At 17 million acres, the Tongass includes vast old growth temperate rainforests that are increasingly rare globally. The Tongass is also a place that has sustained the people and communities of Southeast Alaska for generations. Whether through providing food and other subsistence uses to the rural communities in the region, supporting cultural practices and identity, drawing people to the region for world-class recreation and fishing, or supporting wood products and other forest-based industries, the Tongass is vital to the economic and cultural well-being of the region. The Forest is also important to the climate; while the Tongass comprises about 2 percent of the Nation's forests, according to one scientific study it contains the equivalent of 8 percent of the carbon sequestered in the forests of the conterminous United States. The Department of Agriculture is committed to maintaining Southeast Alaska's exceptional natural resources in perpetuity. USDA is equally committed to doing its part to ensure that the communities within and adjacent to the Tongass National Forest are economically vibrant. These two goals must go hand in hand.

To conserve the Tongass National Forest under the principles of the Multiple-Use Sustained-Yield Act of 1960, Tongass Timber Reform Act and other relevant statutes, we must speed the transition away from old-growth timber harvesting and towards a forest industry that utilizes second growth – or young growth – forests. Moreover, we must do this in a way that preserves a viable timber industry that provides jobs and opportunities for residents of Southeast Alaska.

This Memorandum affirms that this transition to a more ecologically, socially, and economically sustainable forest management is a high priority for USDA, the Forest Service, and the Tongass National Forest. USDA's goal is to effectuate this transition over the next 10 to 15 years, so that at the end of this period the vast majority of timber sold by the Tongass will be young growth. This timeframe will conserve old growth forests while allowing the forest industry time to adapt. To achieve this goal, several steps must be taken as described in the Actions section of this Memorandum.

Over the past three years, USDA has increased investments in alternative economic development opportunities for communities across the region in the recreation, tourism, fishing and renewable energy sectors, while initiating a transition away from a historical reliance on old growth timber harvests. To accomplish the transition to a timber program based primarily on young growth, it is important to retain the expertise and infrastructure of the existing industry so businesses can quickly re-tool. These businesses are fundamental to both the young growth and restoration components of the future timber program, and to the economic vitality of the region. Such an approach requires a reliable supply of economically viable timber, with the old growth component decreasing over time while the young growth component increases.

Updated forest inventories have improved our understanding of the age, location, and amount of young growth across the Tongass, and helped clarify the challenges in establishing an economically viable young growth program due to the relatively young age of the available stands, market conditions, and other factors. Additional research will be necessary to develop effective ways to meet these challenges. Achieving the transition in 10 to 15 years also calls for enactment of a statutory provision, to exempt a limited amount of young growth on the Tongass from current requirements that generally restrict harvesting young growth timber until it reaches maximum growth rates. Administrative mechanisms to accomplish such an adjustment are time consuming and would divert scarce resources from achieving the goals of the transition. Compared to private lands, the Culmination of Mean Annual Increment (CMAI) requirements could delay development of an economically viable young growth program for decades. USDA will continue to work with Congress on such a provision.

To ensure a smooth transition, the Forest Service will continue to offer a supply of old growth timber while increasing the supply of young growth to provide industry in Alaska the opportunity to develop new markets, learn new skills, and acquire new equipment. The continuation of limited sales of old growth timber is essential to maintain the existing industry until young growth can efficiently be processed. The Forest Service will also continue the Tongass National Forest's micro-sale program and the old growth small sale program that targets niche markets, while developing a new integrated program of work focused on young growth, ecological restoration, and forest stewardship that protects and restores the Forest's extraordinary fish and wildlife habitat. This strategy will maintain and restore the Forest's clean water, abundant fish, healthy populations of wildlife, and scenic beauty while sustaining deep-rooted community and cultural ties to the land and providing jobs in the woods.

Through an all lands, all hands approach USDA will utilize all of its expertise, tools and resources such as economic assistance, workforce training, capacity building, and improved

delivery of services to help strengthen and diversify local economies. Working with Rural Development and the Farm Service Agency; other Federal agencies as appropriate; State, local, and Tribal entities; non-governmental organizations; and local communities will be essential to success. Collaborative development of a transition strategy increases collective ownership of the approach; collaborative implementation with our many partners offers opportunities to leverage funding available from the Forest Service.

2. ACTIONS

The objective of this Secretarial Memorandum is to ensure that USDA, the Chief of the Forest Service, the Alaska Region of the Forest Service, and the Tongass National Forest work together to catalyze a transition from a timber sale program based on old growth to one based on young growth. Pursuant to this Memorandum, the Secretary asks the Forest Service to:

a. Seek opportunities to supply sufficient old growth "bridge timber" while the industry re-tools for processing young growth. The first step is the Big Thorne timber sale. This project along with other planned timber sales would supply timber to existing mills for several years and allow the Forest Service to reallocate staff to young growth projects.

b. As soon as possible, allocate staff and financial resources to planning young growth projects, ramping down old growth sales and increasing investments in young growth.

c. Continue to work with Congress to exempt a limited amount of young growth on the Tongass from current requirements that generally restrict harvesting young growth timber until it has reached maximum growth rates, or CMAI. Providing flexibility with regard to CMAI is essential to permit the development of economically viable young growth projects within the timeframe set as a goal for the transition.

d. Develop by July 30, 2013, scenarios that effectuate a more rapid transition by prioritizing and developing additional young growth and restoration projects that could be completed over the next 5 years. Examine scenarios that assume adoption of the statutory provision noted above that provides Forest Service greater flexibility in harvesting young growth timber.

e. Strongly consider whether to pursue an amendment to the Tongass Forest Plan. Such an amendment would evaluate which lands will be available for timber harvest, especially young growth timber stands, which lands should be excluded, and additional opportunities to promote and speed transition to young growth management. A determination of whether to initiate an amendment should be completed by September 30, 2013. If an amendment in pursued, identify an efficient timeline for completion that supports the timeframe for transition outlined in this Memorandum.

f. Continue support for research on how best to manage young growth, develop markets for it, and help industry re-tool to process it. As results become available, apply them as

needed to improve young growth management.

g. Intensify work with Rural Development to pursue opportunities to facilitate investments in re-tooling. Develop by December 31, 2013, in collaboration with Rural Development and other stakeholders, a plan for providing financial assistance to re-tool timber processing equipment in Southeast Alaska to assist the industry to efficiently handle young growth timber.

h. Pursue partnerships with foundations, non-profits, corporations, and others to advance a second growth industry, undertake restoration projects, and otherwise speed the transition.

I will remain engaged in this effort to ensure the Tongass National Forest transitions effectively to a timber program based primarily on young growth. It is vital that the Forest Service continue to seek input from and work with stakeholders in the region towards this transition. In this regard, I will approve establishment of an advisory committee under the Federal Advisory Committee Act to provide advice to the Forest Service on how to expedite the transition to young growth management.

3. MISCELLANEOUS

a. Effective Date. July 1, 2013

b. This Memorandum does not create any right or benefit, substantive or procedural enforceable by law or equity. This Memorandum creates no private right of action.

APPENDIX B: SAMPLE SURVEY

The WORKING FOREST GROUP

Southeast Alaska Future Industry Questionnaire

First Name

Last Name

Mailing Address

City

State

Zip

Daytime Phone Number

E-Mail Address

1. What segment of the Forest Products Industry are you currently active in?
Select All That Apply

- ☐ Manufacturing/Processing
- ☐ Harvesting
- ☐ Logistics
- ☐ Land Owner/Operator
- ☐ Other

2. How many years have you been operating a business and/or been involved in the Forest Products Industry in Southeast Alaska?

How many employees ?

3. Which condition best describes your plan for 10+ years?

- ○ Will operate until I retire and shut down
- ○ Will look for a buyer for my business
- ○ Will or are seeking successor depth now
- ○ Already have a successor in place
- ○ Other

4. What do you think makes a viable forest products industry in Southeast Alaska?

5. Do you think federal, state, or local government should make investments in Southeast Alaska to advance the transition to young growth in the Forest Products Industry?

If **YES**, what area would you prefer that investment take place?
Select One

- ○ Forest Infrastructure (roads, ports, training, etc.)
- ○ Harvesting Equipment Incentives
- ○ Processing and Manufacturing Equipment Incentives
- ○ Other

6. Do you think young growth manufacturing/processing opportunities would be economically viable in Southeast Alaska at ...
Select One

- ○ less than 50 MMBF
- ○ 50-100 MMBF
- ○ 101-200 MMBF

7. Which of the following activities/components would you consider essential for an integrated young growth Forest Products Industry in Southeast Alaska?
Select All That Apply

- ☐ Harvesting
- ☐ Sawmill
- ☐ Value Added Remanufacturing
- ☐ Residual Product Uses, i.e. Energy, Pulp, OSB, MDF
- ☐ Engineered Wood Product LVL/PLGW
- ☐ Log Exporting
- ☐ Other

8. Would your current business be able to operate exclusively from a young growth resource today?

If **NO**, what changes would you need to make to your business?
Select All That Apply

- ☐ Equipment
- ☐ Markets/Customers
- ☐ Workforce Skill Set
- ☐ Products/Services
- ☐ Other

9. **LANDOWNERS ONLY:** (all others go to question #10) Are you committed to keeping your entire managed forest land base in production for the next rotation or harvest?

If **NO,** please explain:

10. If The Working Forest Group (TWFG) proceeds with a 2-day work session in Ketchikan, would you be interested in participating*?

If **YES**, which dates below would fit best into your schedule?
Select All That Apply

- ☐ July 24-25, 2014
- ☐ July 26-27, 2014
- ☐ July 28-29, 2014
- ☐ August 2-3, 2014
- ☐ August 5-6, 2014
- ☐ Other

11. Would you need some financial assistance in order to attend?

** The fifteen participants will be chosen from each of the Forest Products Industry's based on their interest, knowledge, availability, and funding available.*

Additional Comments (optional)

Printed forms can be e-mailed, faxed or mailed to:

E-Mail: info@akworkingforest.org / FAX: 1-866-207-7731/ Mail: TWFG, 2417 Tongass Ave., Suite 111-301, Ketchikan, AK 99901

APPENDIX C: INTIAL BUSINESS CONTACTS – JULY 2014

SE AK Future Industry Contact List
July 2014

#	Business Name	City	State
1	ALASKA FOREST ASSOCIATION INC	KETCHIKAN	AK
2	ALASKA LASER MAID	THORNE BAY	AK
3	ALASKA SPECIALTY WOODS	CRAIG	AK
4	ALCAN FOREST PRODUCTS	KETCHIKAN	AK
5	AMERIKANUAK, INC	JUNEAU	AK
6	BOATRB	PETERSBURG	AK
7	BOYER TOWING COMPANY	KETCHIKAN	AK
8	C. L. REFORESTATION LLC	KLAWOCK	AK
9	CAPITAL CABINETS & COUNTERS	JUNEAU	AK
10	COLUMBIA HELICOPTERS, INC.	KETCHIKAN	AK
11	CORNERSTONE EXCAVATION SERVICES	THORNE BAY	AK
12	CREW ENTERPRISES	SITKA	AK
13	CUTTING EDGE WOOD PRODUCTS	KETCHIKAN	AK
14	D. J. ENTERPRISES	WRANGELL	AK
15	DROSON COMPANY	KLAWOCK	AK
16	DURETTE CONSTRUCTION COMPANY, INC.	KETCHIKAN	AK
17	EIGHT STARS TREE SERVICE	KLAWOCK	AK
18	FALLS CREEK FOREST PRODUCTS	PETERSBURG	AK
19	FIREWEED CRAFTS OF JUNEAU	JUNEAU	AK
20	FOREST INDUSTRY CONSULTING	JUNEAU	AK
21	FRITZ LACOUR	THORNE BAY	AK
22	GILDERSLEEVE LOGGING	GASTON	OR
23	ICY STRAITS LUMBER AND MILLING, INC	HOONAH	AK
24	KLEHINI VALLEY LOG WORKS	HAINES	AK
25	MADISON LUMBER AND HARDWARE	KETCHIKAN	AK
26	MENTAL HEALTH TRUST LAND OFFICE	KETCHIKAN	AK
27	MITKOF TRUCKING	PETERSBURG	AK
28	MOOSE CREEK MILLWORKS	HAINES	AK
29	PAPAC ALASKA LOGGING, INC.	CRAIG	AK
30	PETER M HUBERTH	JUNEAU	AK
31	PHOENIX LOGGING COMPANY	KETCHIKAN	AK
32	PORTER LUMBER	THORNE BAY	AK
33	POW BIOFUELS COOP	THORNE BAY	AK
34	REID BROTHERS LOGGING AND CONSTRUCTION	PETERSBURG	AK
35	ROCK-N-ROAD CONSTRUCTION, INC.	PETERSBURG	AK
36	SAINT NICK FOREST PRODUCTS, INC.	CRAIG	AK
37	SEALASKA TIMBER CORPORATION	KETCHIKAN	AK
38	SOUTHEAST ALASKA RESOURCES	KETCHIKAN	AK
39	SOUTHEAST CEDAR HOMES	SITKA	AK
40	SOUTHEAST ROADBUILDERS	HAINES	AK
41	STATE OF ALASKA, DIVISION OF FORESTRY	KETCHIKAN	AK
42	THE MILL, INC.	PETERSBURG	AK
43	TONGASS FOREST ENTERPRISES	KETCHIKAN	AK
44	TONSGARD LOGGING/CHANNEL CONSTRUCTION	JUNEAU	AK
45	VIKING LUMBER COMPANY, INC.	CRAIG	AK
46	WOOD EYE WOODWORKING	JUNEAU	AK
47	WOODBURY ENTERPRISES	WRANGELL	AK

APPENDIX D: U.S. FOREST SERVICE SOUTHEAST ALASKA SPECIES SUMMARY REPORTS

Species Codes

AC= yellow-cedar

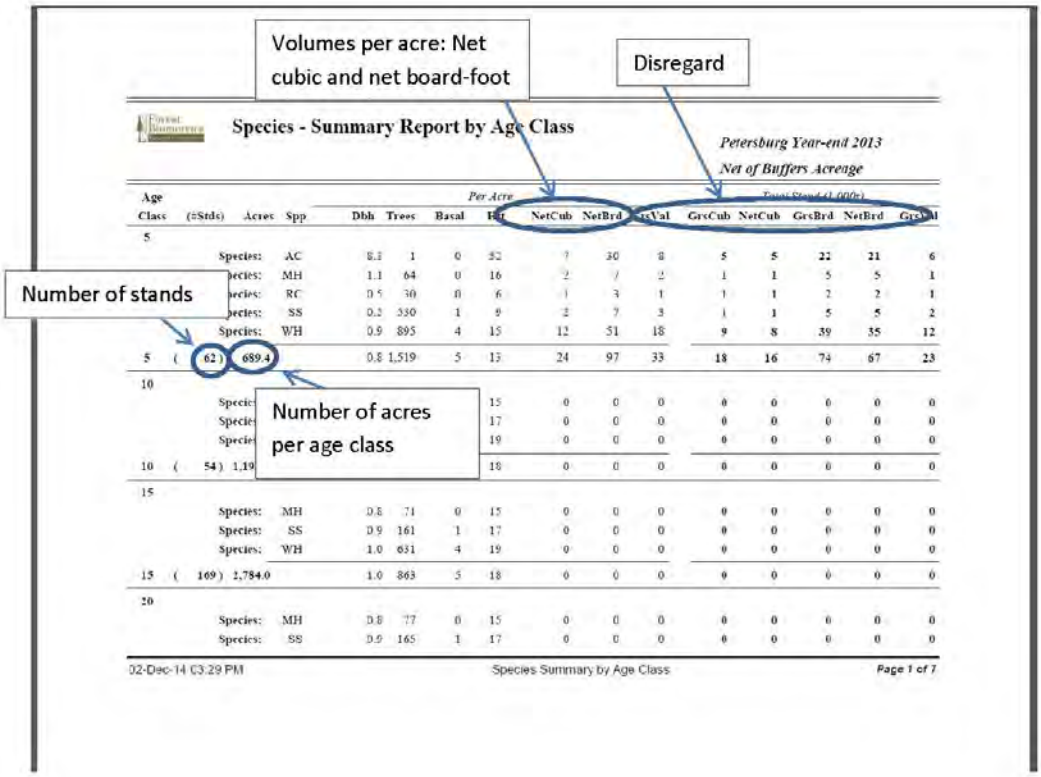
MH = mountain hemlock

RC = western redcedar

SS = Sitka spruce

WH = western hemlock

RA = red alder



Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Dbh	Trees	Basal	Per Acre	NetCub	NetBrd	StsVal	GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
5															
		Species:	AC	8.8	1	0	52	7	30	8	5	5	22	21	6
		Species:	MH	1.1	64	0	16	2	7	2	1	1	5	5	1
		Species:	RC	0.5	30	0	6	1	3	1	1	1	2	2	1
		Species:	SS	0.2	330	1	9	2	7	3	1	1	5	5	2
		Species:	WH	0.9	895	4	15	12	51	18	9	8	39	35	12
5	(62)	689.4		0.8	1,519	5	15	24	97	33	18	16	74	67	23
10															
		Specie					15	0	0	0	0	0	0	0	0
		Specie					17	0	0	0	0	0	0	0	0
		Specie					19	0	0	0	0	0	0	0	0
10	(54)	1,19					18	0	0	0	0	0	0	0	0
15															
		Species:	MH	0.8	71	0	15	0	0	0	0	0	0	0	0
		Species:	SS	0.9	161	1	17	0	0	0	0	0	0	0	0
		Species:	WH	1.0	631	4	19	0	0	0	0	0	0	0	0
15	(169)	2,784.0		1.0	863	5	18	0	0	0	0	0	0	0	0
20															
		Species:	MH	0.8	77	0	15	0	0	0	0	0	0	0	0
		Species:	SS	0.9	165	1	17	0	0	0	0	0	0	0	0

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Species - Summary Report by Age Class

Craig Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
5															
		Species:	AC	1.6	18	0	19	1	3	0	1	1	2	2	0
		Species:	MH	1.1	20	0	16	0	2	0	0	0	1	1	0
		Species:	RC	0.2	162	0	2	0	0	0	0	0	0	0	0
		Species:	SS	0.1	2,194	0	3	0	2	0	0	0	1	1	0
		Species:	WH	0.3	2,105	1	5	1	2	0	0	0	1	1	0
5	(37)	758.6		0.2	4,499	1	4	2	8	2	2	2	6	6	1
10															
		Species:	AC	1.6	70	1	19	4	11	2	3	3	10	9	2
		Species:	MH	1.1	80	0	16	1	7	2	1	1	6	6	1
		Species:	RC	1.5	12	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	243	1	19	2	7	2	2	2	7	6	1
		Species:	WH	1.1	435	3	19	2	7	1	2	2	6	6	1
10	(46)	855.5		1.1	840	6	19	9	32	7	8	8	29	27	6
15															
		Species:	AC	1.6	72	1	20	4	11	2	14	13	40	38	7
		Species:	LP	0.0	0	0	3	0	0	0	0	0	0	0	0
		Species:	MH	1.1	81	1	17	1	8	2	5	5	27	26	6
		Species:	RC	1.5	12	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	242	1	19	2	7	2	6	6	26	25	6
		Species:	WH	1.1	434	3	19	2	7	1	8	7	26	25	5

Species - Summary Report by Age Class

Craig Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
15	(128)	3,427.3		1.1	842	6	19	9	33	7	33	32	119	113	24
20															
	Species:		AC	1.6	70	1	19	4	11	2	16	15	45	42	7
	Species:		MH	1.1	80	0	16	1	7	2	6	5	29	28	7
	Species:		RC	1.5	12	0	9	0	0	0	0	0	0	0	0
	Species:		SS	0.8	243	1	19	2	7	2	7	7	30	29	7
	Species:		WH	1.1	435	3	19	2	7	1	8	8	29	28	6
20	(143)	3,955.9		1.1	840	6	19	9	32	7	37	35	134	127	26
25															
	Species:		AC	2.3	51	1	20	29	119	32	129	123	530	503	137
	Species:		MH	1.1	56	0	16	1	5	1	4	4	22	21	5
	Species:		RA	9.6	0	0	57	2	7	1	10	8	34	30	3
	Species:		RC	2.7	12	0	17	8	28	12	35	34	125	118	51
	Species:		SS	1.8	212	4	25	50	190	62	221	210	845	802	264
	Species:		WH	1.8	426	8	23	25	92	27	112	106	409	389	114
25	(101)	4,231.4		1.8	759	14	23	114	440	136	511	484	1,965	1,863	574
30															
	Species:		AC	12.2	3	3	48	90	381	106	10	10	44	42	12
	Species:		RA	9.7	2	1	57	7	24	3	1	1	3	3	0
	Species:		RC	4.3	12	1	29	27	96	41	3	3	11	11	5

Species - Summary Report by Age Class

Craig Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	SS	3.8	139	11	42	165	631	209	19	18	73	70	23
		Species:	WH	2.9	406	19	29	81	297	89	9	9	35	33	10
30	(11)	110.5		3.4	562	35	33	370	1,428	448	43	41	166	158	50
35															
		Species:	AC	0.1	0	0	48	0	0	0	0	0	0	0	0
		Species:	RA	7.2	8	2	47	25	99	12	16	15	66	58	7
		Species:	RC	2.7	14	1	25	4	16	4	3	3	10	9	2
		Species:	SS	5.0	212	29	43	468	1,576	501	288	273	968	920	292
		Species:	WH	4.0	394	35	39	423	1,430	350	260	247	878	834	204
35	(11)	583.4		4.4	629	67	40	921	3,121	867	567	537	1,922	1,821	506
40															
		Species:	RA	7.2	11	3	47	32	128	16	26	22	102	90	11
		Species:	RC	2.7	18	1	25	6	20	5	4	4	15	14	4
		Species:	SS	5.1	234	34	44	561	1,901	602	412	391	1,395	1,326	420
		Species:	WH	3.9	458	38	39	459	1,547	377	337	320	1,136	1,079	263
40	(18)	697.5		4.4	721	75	41	1,058	3,596	1,001	778	738	2,648	2,509	698
45															
		Species:	AC	7.0	1	0	56	2	6	1	4	4	13	12	2
		Species:	RA	8.2	25	9	53	93	365	54	217	191	849	747	111
		Species:	RC	4.7	24	3	31	23	73	21	50	47	158	150	43

Species - Summary Report by Age Class

Craig Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	SS	7.3	198	57	48	1,213	4,382	1,441	2,614	2,484	9,447	8,974	2,952
		Species:	WH	5.5	361	59	43	1,031	3,993	1,015	2,222	2,111	8,609	8,178	2,079
45	(46)	2,048.1		6.2	608	128	45	2,361	8,819	2,533	5,107	4,836	19,075	18,062	5,187
50															
		Species:	AC	6.1	1	0	38	4	14	3	17	16	52	50	10
		Species:	MH	4.9	0	0	31	1	2	1	3	3	9	9	2
		Species:	RA	8.4	51	20	57	184	692	133	764	673	2,868	2,524	484
		Species:	RC	6.5	37	8	43	99	308	99	380	361	1,183	1,124	360
		Species:	SS	9.8	187	97	62	2,170	7,970	2,662	8,328	7,911	30,590	29,060	9,707
		Species:	WH	7.5	336	103	56	1,789	7,072	1,806	6,864	6,521	27,141	25,784	6,585
50	(74)	3,646.0		8.3	612	228	57	4,247	16,059	4,703	16,357	15,485	61,844	58,551	17,149
55															
		Species:	AC	7.9	0	0	45	3	12	3	13	12	53	50	14
		Species:	LP	8.1	0	0	57	0	1	0	2	2	6	5	1
		Species:	MH	10.4	0	0	51	1	5	1	7	6	22	20	5
		Species:	RA	8.2	64	24	56	229	887	139	1,116	982	4,319	3,800	595
		Species:	RC	5.4	44	7	33	63	198	66	282	268	891	847	283
		Species:	SS	9.5	188	92	59	2,097	7,756	2,559	9,457	8,984	34,969	33,221	10,962
		Species:	WH	7.6	336	105	53	1,962	7,934	2,087	8,848	8,406	35,772	33,984	8,939
55	(56)	4,283.3		8.1	632	228	54	4,356	16,792	4,856	19,724	18,660	76,031	71,927	20,799

Species - Summary Report by Age Class

Craig Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
60															
		Species:	AC	7.2	29	8	48	126	509	126	32	30	128	122	30
		Species:	RA	10.0	19	10	68	126	467	80	34	30	127	112	19
		Species:	RC	7.4	11	3	37	56	178	68	14	13	45	43	16
		Species:	SS	9.6	97	49	72	1,258	4,960	1,628	316	300	1,247	1,185	389
		Species:	WH	9.6	291	145	75	3,588	14,804	4,400	902	857	3,722	3,536	1,051
60	(10)	238.8		9.4	447	216	72	5,153	20,919	6,301	1,298	1,231	5,268	4,996	1,505
65															
		Species:	RA	0.3	0	0	72	0	0	0	0	0	0	0	0
		Species:	SS	6.3	369	79	70	1,960	8,625	3,475	45	43	200	190	77
		Species:	WH	7.4	309	91	76	2,406	10,753	3,637	56	53	249	237	80
65	(5)	22.0		6.8	678	170	73	4,366	19,378	7,112	101	96	449	427	157
70															
		Species:	AC	9.0	9	4	87	118	528	144	1	1	4	4	1
		Species:	MH	11.3	4	3	63	49	174	39	0	0	1	1	0
		Species:	RA	11.3	3	2	72	40	166	18	0	0	1	1	0
		Species:	RC	25.7	2	9	120	375	1,928	916	3	3	14	13	6
		Species:	SS	12.9	105	95	83	3,224	13,819	5,236	23	22	101	96	36
		Species:	WH	8.9	356	154	65	4,369	19,483	6,128	32	30	142	135	42
70	(8)	6.9		10.1	479	267	70	8,175	36,098	12,480	60	57	263	250	86

Species - Summary Report by Age Class

Craig Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
75															
		Species:	AC	9.0	43	19	87	549	2,462	673	12	12	56	53	15
		Species:	MH	11.3	17	12	63	229	812	180	5	5	18	18	4
		Species:	RC	25.7	12	42	120	1,748	8,989	4,269	40	38	204	194	92
		Species:	SS	16.3	45	66	112	2,596	11,945	4,963	59	56	271	258	107
		Species:	WH	12.8	203	183	102	6,878	33,675	12,514	156	148	765	727	270
75	(7)	21.6		13.5	321	322	101	11,999	57,884	22,598	273	259	1,315	1,249	488
80															
		Species:	AC	6.2	18	4	39	36	121	20	1	0	2	2	0
		Species:	RA	8.5	32	13	59	112	438	73	2	2	7	6	1
		Species:	RC	5.7	10	2	33	14	41	12	0	0	1	1	0
		Species:	SS	9.8	135	71	65	1,779	7,038	2,367	25	24	100	95	32
		Species:	WH	8.9	358	155	60	3,596	14,751	4,262	51	49	211	200	58
80	(2)	13.6		9.0	553	244	61	5,538	22,390	6,734	79	75	320	304	91
90															
		Species:	AC	9.0	43	19	87	549	2,462	673	0	0	0	0	0
		Species:	MH	11.3	17	12	63	229	813	180	0	0	0	0	0
		Species:	RC	25.7	12	42	120	1,748	8,989	4,269	0	0	0	0	0
		Species:	SS	16.3	45	66	112	2,596	11,946	4,963	0	0	0	0	0
		Species:	WH	12.8	203	183	102	6,878	33,675	12,514	0	0	0	0	0

Species - Summary Report by Age Class

Craig Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
90	(1)	0.0		13.5	321	322	101	12,000	57,885	22,599	0	0	0	0	0
Sum:	704	24,900.5									44,978	42,575	171,555	162,389	47,348

Species - Summary Report by Age Class

Hoonah Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
10															
		Species:	AC	1.4	5	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	17	0	15	0	0	0	0	0	0	0	0
		Species:	RA	2.1	7	0	20	0	0	0	0	0	0	0	0
		Species:	RC	1.5	7	0	9	0	0	0	0	0	0	0	0
		Species:	SS	1.4	192	2	20	6	25	6	0	0	1	1	0
		Species:	WH	1.0	300	2	18	0	0	0	0	0	0	0	0
10	(5)	32.3		1.2	528	4	19	6	25	6	0	0	1	1	0
15															
		Species:	AC	1.4	5	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	17	0	15	0	0	0	0	0	0	0	0
		Species:	RA	2.1	7	0	20	0	0	0	0	0	0	0	0
		Species:	RC	1.5	7	0	9	0	0	0	0	0	0	0	0
		Species:	SS	1.4	192	2	20	6	25	6	2	2	9	9	2
		Species:	WH	1.0	300	2	18	0	0	0	0	0	0	0	0
15	(9)	344.9		1.2	528	4	19	6	25	6	2	2	9	9	2
20															
		Species:	AC	1.4	5	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	17	0	15	0	0	0	0	0	0	0	0
		Species:	RA	2.1	7	0	20	0	0	0	0	0	0	0	0
		Species:	RC	1.5	7	0	9	0	0	0	0	0	0	0	0

Species - Summary Report by Age Class

Hoonah Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	SS	1.4	192	2	20	6	25	6	31	29	127	121	28
		Species:	WH	1.0	300	2	18	0	0	0	0	0	0	0	0
20	(121)	4,808.5		1.2	528	4	19	6	25	6	31	29	127	121	28
25															
		Species:	AC	4.1	4	0	20	11	47	13	66	62	278	264	74
		Species:	MH	0.8	13	0	15	0	0	0	0	0	0	0	0
		Species:	RA	2.4	6	0	21	0	0	0	0	0	0	0	0
		Species:	RC	2.4	7	0	15	3	12	5	20	19	70	66	28
		Species:	SS	1.7	212	3	25	16	61	15	97	92	363	345	86
		Species:	WH	1.4	380	4	24	14	47	13	81	77	283	269	73
25	(165)	5,674.3		1.6	622	8	24	44	166	46	263	250	994	944	261
30															
		Species:	AC	13.1	2	2	57	51	216	60	145	138	614	583	163
		Species:	RA	8.3	1	0	54	0	0	0	0	0	0	0	0
		Species:	RC	4.3	7	1	29	15	54	23	44	42	154	147	63
		Species:	SS	2.1	301	7	33	53	189	49	150	143	538	511	131
		Species:	WH	1.9	700	13	30	64	224	61	182	173	635	604	164
30	(66)	2,698.3		2.0	1,010	23	31	184	683	193	521	495	1,941	1,844	520
35															
		Species:	AC	8.8	4	2	41	52	221	62	82	78	346	329	92

Species - Summary Report by Age Class

Hoonah Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RA	7.3	6	2	45	15	60	8	26	22	102	90	12
		Species:	RC	4.1	14	1	31	21	70	27	33	31	110	104	40
		Species:	SS	3.2	308	17	36	257	900	272	402	382	1,410	1,340	406
		Species:	WH	2.3	717	21	34	209	775	208	327	311	1,215	1,154	310
35	(42)	1,488.7		2.7	1,049	42	35	554	2,026	577	870	824	3,183	3,017	859
40															
		Species:	AC	4.8	2	0	28	9	39	11	0	0	1	1	0
		Species:	RA	9.5	67	33	54	302	1,171	184	10	9	40	36	6
		Species:	RC	3.8	8	1	33	8	25	8	0	0	1	1	0
		Species:	SS	7.0	299	81	53	1,817	6,279	2,071	58	55	201	191	63
		Species:	WH	3.8	451	36	48	702	2,521	627	22	21	81	77	19
40	(6)	30.4		5.8	828	151	50	2,838	10,035	2,901	92	86	324	305	88
45															
		Species:	AC	4.8	13	2	28	51	218	62	0	0	0	0	0
		Species:	RA	7.2	29	8	44	87	345	45	0	0	1	1	0
		Species:	RC	3.8	47	4	33	45	138	42	0	0	0	0	0
		Species:	SS	5.6	367	62	45	1,217	4,245	1,327	2	2	7	7	2
		Species:	WH	3.6	841	58	46	890	3,371	899	1	1	5	5	1
45	(1)	1.5		4.3	1,298	134	45	2,290	8,317	2,376	4	4	13	13	4
50															

Species - Summary Report by Age Class

Hoonah Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RA	7.7	36	12	48	132	515	81	88	77	343	302	48
		Species:	RC	4.5	56	6	34	46	138	40	28	27	85	81	24
		Species:	SS	8.1	269	96	51	2,310	8,478	2,863	1,427	1,355	5,236	4,974	1,680
		Species:	WH	5.1	569	82	46	1,513	5,801	1,441	935	888	3,583	3,403	845
50	(11)	586.7		6.2	929	196	47	4,001	14,932	4,425	2,478	2,347	9,247	8,760	2,596
55															
		Species:	RA	7.9	33	11	48	125	486	79	14	13	56	50	8
		Species:	RC	4.5	62	7	34	51	154	45	6	5	17	16	5
		Species:	SS	8.2	256	94	51	2,236	8,173	2,770	241	229	879	835	283
		Species:	WH	5.2	571	84	46	1,522	5,840	1,454	164	156	628	597	149
55	(3)	102.2		6.2	922	195	47	3,935	14,654	4,348	424	402	1,581	1,498	444
60															
		Species:	RA	11.3	4	3	72	56	231	25	0	0	0	0	0
		Species:	SS	12.6	130	112	80	3,689	15,553	5,781	0	0	1	1	0
		Species:	WH	8.0	395	137	58	3,420	14,512	4,054	0	0	1	1	0
60	(1)	0.1		9.4	529	252	64	7,165	30,296	9,860	1	1	2	2	1
75															
		Species:	RA	11.3	4	3	72	56	231	25	0	0	0	0	0
		Species:	SS	12.6	130	112	80	3,689	15,553	5,781	1	0	2	2	1
		Species:	WH	8.0	395	137	58	3,420	14,512	4,054	0	0	2	2	1

Species - Summary Report by Age Class

Hoonah Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
75	(1)	0.1		9.4	529	252	64	7,165	30,296	9,860	1	1	4	4	1
100															
	Species:		AC	9.0	43	19	87	549	2,462	673	1	1	5	4	1
	Species:		MH	11.3	17	12	63	229	813	180	0	0	1	1	0
	Species:		RC	25.7	12	42	120	1,748	8,989	4,269	3	3	16	16	7
	Species:		SS	16.3	45	66	112	2,596	11,946	4,963	5	5	22	21	9
	Species:		WH	12.8	203	183	102	6,878	33,675	12,514	13	12	62	59	22
100	(1)	1.7		13.5	321	322	101	12,000	57,885	22,599	22	21	106	101	39
Sum:	432	15,769.8									4,708	4,463	17,533	16,617	4,845

Species - Summary Report by Age Class

Juneau Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
20															
		Species:	AC	1.4	9	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	34	0	15	0	0	0	0	0	0	0	0
		Species:	RC	1.5	14	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	266	1	19	2	8	2	2	2	7	7	2
		Species:	WH	1.1	472	3	19	0	0	0	0	0	0	0	0
20	(19)	796.8		1.0	795	4	19	2	8	2	2	2	7	7	2
25															
		Species:	AC	1.4	9	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	34	0	15	0	0	0	0	0	0	0	0
		Species:	RC	1.5	14	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	266	1	19	2	8	2	1	1	6	5	1
		Species:	WH	1.1	472	3	19	0	0	0	0	0	0	0	0
25	(14)	657.0		1.0	795	4	19	2	8	2	1	1	6	5	1
30															
		Species:	AC	12.2	3	3	48	90	381	106	41	39	172	163	46
		Species:	RA	9.7	2	1	57	7	24	3	3	3	12	10	1
		Species:	RC	4.3	12	1	29	27	96	41	12	12	43	41	18
		Species:	SS	3.8	139	11	42	165	631	209	75	71	285	271	90
		Species:	WH	2.9	406	19	29	81	297	89	36	35	134	128	38

Species - Summary Report by Age Class

Juneau Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
30	(7)	429.5		3.4	562	35	33	370	1,428	448	167	159	647	613	192
35															
	Species:		AC	5.6	11	2	30	59	252	72	24	23	102	97	27
	Species:		RA	7.2	23	7	44	70	279	37	31	27	121	107	14
	Species:		RC	3.9	40	3	33	41	129	42	17	16	52	50	16
	Species:		SS	5.4	320	51	45	999	3,495	1,096	403	383	1,411	1,340	420
	Species:		WH	3.5	751	50	44	722	2,733	731	292	277	1,103	1,048	280
35	(4)	383.4		4.3	1,145	113	44	1,892	6,888	1,976	766	725	2,789	2,641	758
40															
	Species:		AC	4.8	13	2	28	51	218	62	26	25	113	107	31
	Species:		RA	7.2	29	8	44	87	345	45	48	42	192	169	22
	Species:		RC	3.8	47	4	33	45	138	42	23	22	71	68	20
	Species:		SS	5.6	367	62	45	1,217	4,245	1,327	627	596	2,188	2,078	650
	Species:		WH	3.6	841	58	46	890	3,371	899	459	436	1,738	1,650	440
40	(12)	489.6		4.3	1,298	134	45	2,290	8,317	2,376	1,184	1,121	4,301	4,072	1,163
45															
	Species:		AC	4.8	7	1	28	26	111	32	50	47	211	200	57
	Species:		RA	7.5	31	10	46	106	416	62	216	190	850	748	112
	Species:		RC	4.2	55	5	34	48	146	44	92	87	278	264	78
	Species:		SS	6.7	313	77	47	1,713	6,153	2,028	3,247	3,085	11,664	11,080	3,651

Species - Summary Report by Age Class

Juneau Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	4.3	709	70	46	1,196	4,564	1,165	2,268	2,154	8,652	8,218	2,099
45	(16)	1,800.8		5.2	1,115	164	46	3,089	11,390	3,330	5,872	5,563	21,654	20,511	5,997
60															
		Species:	SS	12.3	194	160	70	4,818	19,147	7,013	3	3	13	13	5
		Species:	WH	8.3	290	108	59	2,545	10,462	2,951	2	2	7	7	2
60	(2)	0.7		10.1	485	268	64	7,363	29,609	9,964	5	5	21	20	7
65															
		Species:	SS	12.3	194	160	70	4,818	19,147	7,013	72	69	288	273	100
		Species:	WH	8.3	290	108	59	2,545	10,462	2,951	38	36	157	149	42
65	(1)	14.3		10.1	485	268	64	7,363	29,609	9,964	111	105	445	423	142
Sum:	75	4,572.1									8,109	7,682	29,870	28,292	8,262

Species - Summary Report by Age Class

Ketchikan Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
5															
		Species:	AC	5.4	2	0	26	10	43	12	14	14	61	58	16
		Species:	MH	0.8	3	0	15	0	0	0	0	0	0	0	0
		Species:	RA	8.0	19	7	52	82	296	46	125	110	453	398	62
		Species:	RC	2.6	50	2	18	17	52	16	23	22	74	70	21
		Species:	SS	4.1	671	60	30	1,495	5,673	2,008	2,120	2,014	8,045	7,643	2,705
		Species:	WH	3.5	851	56	34	1,163	4,681	1,369	1,654	1,567	6,662	6,307	1,845
		Species:	YC	0.0	4	0	1	0	0	0	0	0	0	0	0
5	(19)	1,347.3		3.8	1,600	125	32	2,767	10,745	3,451	3,938	3,728	15,295	14,476	4,649
10															
		Species:	AC	4.4	11	1	39	30	134	38	78	74	347	330	92
		Species:	MH	1.9	32	1	17	11	41	9	30	28	107	101	22
		Species:	RC	7.3	14	4	34	136	657	312	360	333	1,740	1,612	765
		Species:	SS	1.8	247	5	22	144	676	288	373	354	1,747	1,660	706
		Species:	WH	2.4	464	14	26	383	1,806	661	989	939	4,666	4,433	1,623
10	(118)	2,454.1		2.4	767	24	25	704	3,315	1,307	1,828	1,728	8,607	8,135	3,208
15															
		Species:	AC	1.4	9	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	34	0	15	0	0	0	0	0	0	0	0
		Species:	RC	1.5	14	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	266	1	19	2	6	1	9	9	27	25	6

Species - Summary Report by Age Class

Ketchikan Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	1.1	472	3	19	0	0	0	0	0	0	0	0
15	(159)	4,573.8		1.0	795	4	19	2	6	1	9	9	27	25	6
20															
		Species:	AC	1.4	9	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	34	0	15	0	0	0	0	0	0	0	0
		Species:	RC	1.5	14	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	266	1	19	2	6	1	8	8	23	21	5
		Species:	WH	1.1	472	3	19	0	0	0	0	0	0	0	0
20	(127)	3,898.9		1.0	795	4	19	2	6	1	8	8	23	21	5
25															
		Species:	AC	4.4	8	1	19	23	98	28	87	83	375	356	100
		Species:	MH	0.8	25	0	15	0	0	0	0	0	0	0	0
		Species:	RA	9.6	0	0	57	2	6	1	8	7	26	23	3
		Species:	RC	2.5	13	0	16	7	23	10	25	24	89	84	38
		Species:	SS	1.7	232	4	24	43	160	52	166	157	611	580	188
		Species:	WH	1.7	455	7	22	21	78	23	78	74	298	283	84
25	(67)	3,623.1		1.8	734	12	22	96	366	114	365	346	1,398	1,326	412
30															
		Species:	AC	12.2	3	3	48	87	374	105	169	161	729	692	194
		Species:	RA	9.7	2	1	57	8	24	3	16	14	50	44	5

Species - Summary Report by Age Class

Ketchikan Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RC	4.3	12	1	29	25	88	40	50	47	172	164	73
		Species:	SS	3.8	139	11	42	160	594	194	312	296	1,159	1,099	359
		Species:	WH	2.9	406	19	29	78	297	89	152	145	579	550	164
30	(33)	1,851.2		3.4	562	35	33	358	1,377	429	700	663	2,689	2,549	795
35															
		Species:	AC	7.5	7	2	34	67	288	81	197	187	839	797	224
		Species:	RA	8.0	16	6	48	65	237	33	204	180	745	656	91
		Species:	RC	4.0	25	2	32	31	99	37	90	85	287	273	101
		Species:	SS	5.2	237	35	45	656	2,190	690	1,914	1,818	6,386	6,066	1,912
		Species:	WH	3.3	576	35	40	419	1,573	418	1,223	1,161	4,588	4,358	1,158
35	(57)	2,769.8		4.1	861	80	42	1,239	4,386	1,259	3,628	3,431	12,845	12,149	3,486
40															
		Species:	AC	4.8	13	2	28	49	203	57	126	120	526	500	141
		Species:	RA	7.3	30	9	45	106	392	52	295	260	1,094	963	128
		Species:	RC	3.8	46	4	33	42	124	37	108	103	320	304	90
		Species:	SS	5.6	365	63	45	1,191	3,903	1,210	3,081	2,927	10,099	9,593	2,974
		Species:	WH	3.6	830	57	46	857	3,233	856	2,219	2,108	8,367	7,947	2,103
40	(38)	2,458.1		4.4	1,284	134	45	2,244	7,854	2,212	5,830	5,517	20,406	19,307	5,436
45															
		Species:	AC	4.8	8	1	28	31	129	36	39	37	161	153	43

Species - Summary Report by Age Class

Ketchikan Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	MH	3.0	15	1	16	0	0	0	0	0	0	0	0
		Species:	RA	7.7	30	10	49	133	481	79	179	158	649	571	93
		Species:	RC	3.4	70	4	31	35	105	31	43	41	131	124	36
		Species:	SS	6.3	283	61	47	1,235	4,139	1,294	1,549	1,467	5,188	4,918	1,538
		Species:	WH	4.3	706	73	45	1,158	4,235	1,073	1,449	1,376	5,300	5,032	1,275
45	(23)	1,188.3		5.0	1,112	149	45	2,591	9,087	2,513	3,260	3,079	11,428	10,799	2,986
50															
		Species:	AC	11.5	0	0	47	2	5	1	5	5	13	13	2
		Species:	MH	3.1	40	2	16	0	0	0	0	0	0	0	0
		Species:	RA	8.2	34	13	57	193	684	132	502	442	1,783	1,569	302
		Species:	RC	3.1	104	5	28	21	66	19	50	48	160	152	43
		Species:	SS	8.4	158	60	53	1,367	4,776	1,526	3,319	3,134	11,567	10,947	3,498
		Species:	WH	5.9	495	93	45	1,590	5,650	1,392	3,840	3,646	13,642	12,951	3,191
50	(70)	2,292.4		6.2	832	173	45	3,173	11,182	3,070	7,717	7,275	27,165	25,632	7,038
55															
		Species:	AC	1.0	1	0	9	0	0	0	0	0	0	0	0
		Species:	MH	3.0	28	1	16	0	0	0	0	0	0	0	0
		Species:	RA	8.1	28	10	55	150	531	100	340	300	1,206	1,061	199
		Species:	RC	3.2	79	4	29	18	59	17	39	37	125	118	34
		Species:	SS	8.5	191	75	57	1,751	6,373	2,073	3,695	3,496	13,432	12,730	4,141
		Species:	WH	5.9	498	94	47	1,601	5,840	1,495	3,369	3,198	12,286	11,665	2,986

Species - Summary Report by Age Class

Ketchikan Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
55	(60)	1,997.4		6.4	823	184	48	3,520	12,804	3,684	7,442	7,031	27,048	25,575	7,359
60															
	Species:		RA	10.5	4	2	59	26	92	10	38	34	133	117	13
	Species:		RC	12.6	2	2	51	49	226	108	67	63	305	290	138
	Species:		SS	9.7	192	98	67	2,596	10,220	3,521	3,505	3,330	13,798	13,108	4,515
	Species:		WH	6.5	427	97	59	1,911	7,729	2,371	2,580	2,451	10,434	9,913	3,041
60	(35)	1,282.5		7.6	625	199	62	4,582	18,267	6,009	6,189	5,877	24,670	23,428	7,707
65															
	Species:		AC	9.0	5	2	87	59	259	72	1	1	3	3	1
	Species:		MH	11.3	2	1	63	31	113	24	0	0	1	1	0
	Species:		RA	10.5	1	1	59	8	27	3	0	0	0	0	0
	Species:		RC	15.0	10	12	63	412	1,982	945	5	4	23	22	10
	Species:		SS	11.4	108	77	75	2,340	9,565	3,532	27	26	110	104	39
	Species:		WH	6.5	619	144	63	3,403	14,500	4,661	39	37	166	158	51
65	(4)	10.9		7.6	745	237	65	6,254	26,446	9,237	72	68	303	288	101
70															
	Species:		AC	8.9	1	0	87	8	36	10	0	0	1	1	0
	Species:		MH	11.1	0	0	63	4	15	3	0	0	0	0	0
	Species:		RC	12.8	14	12	51	391	1,808	867	8	8	39	37	18
	Species:		SS	13.0	71	65	81	2,122	8,751	3,306	45	43	187	178	67

Species - Summary Report by Age Class

Ketchikan Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	6.1	790	162	61	3,638	15,081	4,654	78	74	323	307	95
70	(2)	20.3		7.1	876	240	63	6,163	25,691	8,841	132	125	550	523	180
75															
		Species:	RC	16.9	24	37	66	1,213	5,774	2,805	22	21	107	101	49
		Species:	SS	10.1	40	22	75	705	2,857	1,160	13	12	53	50	20
		Species:	WH	5.2	1,190	176	64	3,763	15,399	5,258	69	66	284	270	92
75	(2)	17.5		5.9	1,254	236	64	5,681	24,030	9,223	105	100	444	422	162
80															
		Species:	AC	9.0	43	19	87	534	2,330	647	70	67	306	290	81
		Species:	MH	11.3	17	12	63	280	1,014	215	37	35	133	126	27
		Species:	RC	25.7	12	42	120	1,655	8,395	3,972	217	206	1,101	1,046	495
		Species:	SS	16.3	45	66	112	2,497	11,162	4,591	328	311	1,464	1,391	572
		Species:	WH	12.8	203	183	102	6,650	32,158	11,866	872	829	4,218	4,007	1,479
80	(4)	124.6		13.5	321	322	101	11,617	55,059	21,292	1,524	1,448	7,222	6,861	2,653
90															
		Species:	AC	9.0	38	17	87	471	2,051	570	438	416	1,909	1,814	504
		Species:	MH	11.3	15	11	63	247	893	190	230	218	831	790	168
		Species:	RA	10.4	0	0	59	3	12	1	3	3	12	10	1
		Species:	RC	25.7	10	37	120	1,457	7,391	3,497	1,357	1,289	6,880	6,536	3,093
		Species:	SS	14.0	66	71	96	2,531	11,122	4,479	2,356	2,238	10,352	9,835	3,961

Species - Summary Report by Age Class

Ketchikan Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
	Species:		WH	11.8	225	172	95	6,054	29,106	10,687	5,635	5,353	27,092	25,737	9,450
90	(45)	884.3		12.6	355	307	94	10,763	50,575	19,424	10,018	9,517	47,076	44,722	17,176
100															
	Species:		AC	9.0	43	19	87	534	2,330	647	1	1	5	5	1
	Species:		MH	11.3	17	12	63	280	1,014	215	1	1	2	2	0
	Species:		RC	25.7	12	42	120	1,655	8,395	3,972	4	3	18	18	8
	Species:		SS	16.3	45	66	112	2,497	11,162	4,591	6	5	25	23	10
	Species:		WH	12.8	203	183	102	6,650	32,158	11,866	15	14	71	67	25
100	(2)	2.1		13.5	321	322	101	11,617	55,059	21,292	26	24	121	115	45
Sum:	865	30,796.8									52,790	49,974	207,318	196,353	63,403

Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
5															
		Species:	AC	8.3	1	0	52	7	30	8	5	5	22	21	6
		Species:	MH	1.1	64	0	16	2	7	2	1	1	5	5	1
		Species:	RC	0.5	30	0	6	1	3	1	1	1	2	2	1
		Species:	SS	0.5	530	1	9	2	7	3	1	1	5	5	2
		Species:	WH	0.9	895	4	15	12	51	18	9	8	39	35	12
5	(62)	689.4		0.8	1,519	5	13	24	97	33	18	16	74	67	23
10															
		Species:	MH	0.8	74	0	15	0	0	0	0	0	0	0	0
		Species:	SS	0.9	165	1	17	0	0	0	0	0	0	0	0
		Species:	WH	1.0	618	4	19	0	0	0	0	0	0	0	0
10	(54)	1,195.2		1.0	857	5	18	0	0	0	0	0	0	0	0
15															
		Species:	MH	0.8	71	0	15	0	0	0	0	0	0	0	0
		Species:	SS	0.9	161	1	17	0	0	0	0	0	0	0	0
		Species:	WH	1.0	631	4	19	0	0	0	0	0	0	0	0
15	(169)	2,784.0		1.0	863	5	18	0	0	0	0	0	0	0	0
20															
		Species:	MH	0.8	77	0	15	0	0	0	0	0	0	0	0
		Species:	SS	0.9	165	1	17	0	0	0	0	0	0	0	0

Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	1.0	616	4	19	0	0	0	0	0	0	0	0
20	(133)	4,962.9		1.0	857	5	18	0	0	0	0	0	0	0	0
25															
		Species:	AC	3.3	0	0	25	0	0	0	0	0	0	0	0
		Species:	MH	1.0	53	0	15	1	1	0	5	5	13	12	3
		Species:	RC	2.4	1	0	18	0	0	0	0	0	0	0	0
		Species:	SS	1.6	143	2	20	9	34	9	85	78	326	303	82
		Species:	WH	1.5	495	6	21	9	34	9	86	80	318	296	76
25	(202)	8,808.4		1.5	691	9	21	19	69	18	176	164	657	611	161
30															
		Species:	AC	3.4	0	0	25	0	0	0	0	0	0	0	0
		Species:	MH	8.7	1	0	50	2	5	1	11	11	27	26	6
		Species:	RC	2.5	2	0	18	0	0	0	0	0	0	0	0
		Species:	SS	3.2	87	5	31	32	126	34	176	163	679	630	172
		Species:	WH	3.5	196	13	33	33	123	32	179	167	663	617	159
30	(123)	5,017.0		3.4	287	19	33	68	254	67	367	341	1,369	1,274	337
35															
		Species:	AC	3.4	0	0	25	0	0	0	0	0	0	0	0
		Species:	MH	8.7	0	0	50	1	4	1	16	15	39	37	9
		Species:	RA	6.6	8	2	44	16	65	9	188	165	765	673	91

Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RC	2.5	1	0	18	0	0	0	0	0	0	0	0
		Species:	SS	4.6	255	30	45	549	1,923	599	6,013	5,706	21,054	19,979	6,218
		Species:	WH	3.2	458	26	39	279	1,021	247	3,056	2,899	11,183	10,605	2,565
35	(178)	########		3.8	723	58	41	846	3,013	855	9,274	8,785	33,041	31,294	8,883
40															
		Species:	AC	1.7	13	0	11	2	7	1	14	13	51	48	8
		Species:	LP	4.2	0	0	26	0	0	0	0	0	0	0	0
		Species:	MH	2.3	2	0	15	0	1	0	3	2	7	5	1
		Species:	RA	6.3	20	4	42	33	135	18	275	242	1,116	982	133
		Species:	RC	0.0	1	0	3	0	0	0	0	0	0	0	0
		Species:	SA	1.0	1	0	9	0	0	0	0	0	0	0	0
		Species:	SF	7.7	0	0	39	1	2	0	4	4	13	13	3
		Species:	SS	4.8	572	71	46	1,323	4,551	1,407	10,145	9,637	34,899	33,152	10,248
		Species:	WH	3.1	944	49	39	668	2,425	577	5,124	4,868	18,600	17,668	4,201
40	(103)	7,284.7		3.8	1,553	124	42	2,027	7,120	2,003	15,565	14,765	54,686	51,869	14,594
45															
		Species:	AC	1.9	30	1	16	2	7	1	13	13	48	45	6
		Species:	BC	11.5	0	0	72	4	15	3	30	26	116	102	19
		Species:	LP	2.0	2	0	20	0	0	0	0	0	0	0	0
		Species:	MH	1.3	6	0	10	0	1	0	3	3	7	6	1
		Species:	RA	6.4	30	7	50	46	178	23	346	304	1,353	1,191	157

Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RC	6.9	0	0	37	0	0	0	0	0	0	0	0
		Species:	SA	1.6	3	0	17	0	0	0	0	0	0	0	0
		Species:	SS	5.3	569	86	52	1,693	5,872	1,862	11,906	11,310	41,287	39,222	12,435
		Species:	WH	3.2	916	52	41	806	2,929	748	5,664	5,381	20,596	19,566	4,996
45	(107)	6,679.3		4.1	1,556	145	45	2,551	9,003	2,637	17,962	17,037	63,406	60,132	17,614
50															
		Species:	AC	3.1	12	1	25	8	30	7	35	33	134	127	31
		Species:	BC	7.7	0	0	53	0	0	0	0	0	0	0	0
		Species:	MH	0.9	4	0	8	0	0	0	0	0	0	0	0
		Species:	RA	6.4	38	9	48	81	308	45	391	344	1,493	1,314	190
		Species:	RC	4.8	2	0	28	2	7	2	9	9	30	29	8
		Species:	SS	6.7	390	96	57	2,311	8,480	2,932	10,367	9,849	38,042	36,140	12,498
		Species:	WH	3.4	908	58	47	1,021	3,825	976	4,580	4,351	17,162	16,304	4,159
50	(119)	4,262.0		4.7	1,354	164	50	3,422	12,650	3,962	15,382	14,585	56,861	53,914	16,887
55															
		Species:	AC	2.4	11	0	22	2	7	1	2	2	6	6	1
		Species:	MH	0.6	2	0	9	0	0	0	0	0	0	0	0
		Species:	RA	6.0	16	3	48	24	95	12	21	19	86	75	9
		Species:	SS	7.7	353	114	59	2,814	10,931	3,665	2,360	2,242	9,167	8,709	2,920
		Species:	WH	4.6	617	71	45	1,373	5,483	1,491	1,151	1,094	4,598	4,368	1,188

Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
55	(45)	796.7		5.9	998	188	50	4,212	16,516	5,169	3,534	3,356	13,857	13,158	4,118
60															
		Species:	SS	12.2	196	160	70	4,799	19,075	6,982	180	171	715	680	249
		Species:	WH	8.2	290	108	59	2,536	10,428	2,942	95	90	391	372	105
60	(6)	35.6		10.0	486	267	64	7,335	29,503	9,924	275	261	1,106	1,051	354
65															
		Species:	AC	9.0	8	4	87	103	463	127	26	24	115	110	30
		Species:	MH	11.3	3	2	63	43	153	34	11	10	38	36	8
		Species:	RC	25.7	2	8	120	329	1,691	803	82	78	421	400	190
		Species:	SS	11.1	193	129	78	3,938	16,077	5,894	981	932	4,006	3,805	1,395
		Species:	WH	8.7	273	114	67	3,156	14,034	4,528	786	747	3,497	3,322	1,072
65	(18)	236.7		9.9	480	257	72	7,569	32,418	11,385	1,886	1,792	8,077	7,673	2,695
70															
		Species:	AC	9.0	30	13	87	375	1,680	459	11	11	50	47	13
		Species:	MH	11.3	12	8	63	156	555	123	5	4	16	16	3
		Species:	RC	25.7	8	29	120	1,193	6,136	2,914	35	34	182	173	82
		Species:	SS	11.2	120	82	89	2,838	12,517	4,927	84	80	372	353	139
		Species:	WH	11.0	231	152	88	5,352	25,758	9,353	159	151	765	727	264
70	(5)	28.2		11.4	401	285	88	9,914	46,646	17,776	295	280	1,386	1,317	502

Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
75															
		Species:	AC	9.0	43	19	87	549	2,462	673	1	1	6	6	2
		Species:	MH	11.3	17	12	63	229	813	180	1	1	2	2	0
		Species:	RC	25.7	12	42	120	1,748	8,989	4,269	4	4	22	21	10
		Species:	SS	16.3	45	66	112	2,596	11,946	4,963	6	6	29	28	11
		Species:	WH	12.8	203	183	102	6,878	33,675	12,514	17	16	82	78	29
75	(2)	2.3		13.5	321	322	101	12,000	57,885	22,599	29	28	141	134	52
80															
		Species:	AC	9.0	40	18	87	509	2,280	623	8	8	36	35	9
		Species:	MH	11.3	16	11	63	212	752	166	3	3	12	11	3
		Species:	RC	25.7	11	39	120	1,619	8,324	3,953	26	25	133	126	60
		Species:	SS	15.4	56	73	103	2,760	12,479	5,115	44	42	199	190	78
		Species:	WH	12.4	210	177	99	6,557	31,958	11,806	105	100	511	485	179
80	(7)	15.2		13.2	333	318	97	11,656	55,793	21,664	186	177	892	847	329
90															
		Species:	AC	9.0	43	19	87	546	2,448	669	99	94	446	423	116
		Species:	MH	11.3	17	12	63	227	808	179	41	39	147	140	31
		Species:	RC	25.7	12	42	120	1,738	8,938	4,244	316	301	1,627	1,546	734
		Species:	SS	16.2	46	66	111	2,608	11,987	4,975	475	451	2,183	2,074	861
		Species:	WH	12.8	204	182	102	6,853	33,542	12,459	1,248	1,186	6,108	5,802	2,155

Species - Summary Report by Age Class

Petersburg Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
90	(19)	173.0		13.5	322	321	101	11,973	57,722	22,526	2,180	2,071	10,511	9,985	3,897
100															
	Species:		AC	9.0	41	18	87	520	2,333	638	31	30	140	133	36
	Species:		MH	11.3	16	11	63	217	770	170	13	12	46	44	10
	Species:		RC	25.7	11	40	120	1,656	8,517	4,045	99	94	510	485	230
	Species:		SS	14.9	57	69	105	2,649	12,088	4,970	159	151	724	688	283
	Species:		WH	12.5	208	178	100	6,622	32,346	11,981	397	377	1,938	1,841	682
100	(6)	56.9		13.2	334	316	99	11,664	56,054	21,803	699	664	3,358	3,190	1,241
Sum:	1,358	53,415.2									67,827	64,322	249,422	236,516	71,685

Species - Summary Report by Age Class

Thorne Bay Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
5															
		Species:	MH	1.1	7	0	6	0	0	0	0	0	0	0	0
		Species:	RC	2.1	25	1	11	0	0	0	0	0	0	0	0
		Species:	SS	1.0	218	1	13	0	0	0	0	0	0	0	0
		Species:	WH	1.4	507	5	19	2	7	1	1	1	5	5	1
5	(97)	703.7		1.3	757	7	17	2	7	1	1	1	5	5	1
10															
		Species:	MH	1.1	7	0	6	0	0	0	0	0	0	0	0
		Species:	RC	2.1	26	1	11	0	0	0	0	0	0	0	0
		Species:	SS	0.9	235	1	12	0	0	0	0	0	0	0	0
		Species:	WH	1.3	547	5	20	2	8	1	4	4	15	14	2
10	(87)	1,661.6		1.2	814	7	18	2	8	1	4	4	15	14	2
15															
		Species:	MH	1.1	7	0	6	0	0	0	0	0	0	0	0
		Species:	RC	2.1	25	1	11	0	0	0	0	0	0	0	0
		Species:	SS	1.0	218	1	13	0	0	0	0	0	0	0	0
		Species:	WH	1.4	507	5	19	2	7	1	9	8	34	33	5
15	(198)	4,780.7		1.3	757	7	17	2	7	1	9	8	34	33	5
20															
		Species:	MH	1.1	7	0	7	0	0	0	0	0	1	1	0

Species - Summary Report by Age Class

Thorne Bay Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RC	2.1	25	1	11	0	0	0	0	0	0	0	0
		Species:	SS	1.0	217	1	13	0	0	0	2	2	7	7	1
		Species:	WH	1.4	509	5	19	2	7	1	29	28	117	111	17
20	(422)	########		1.3	758	7	17	2	7	1	32	30	126	119	18
25															
		Species:	AC	5.4	1	0	32	3	9	2	58	55	188	179	31
		Species:	LP	4.4	2	0	28	0	0	0	0	0	0	0	0
		Species:	MH	1.1	4	0	6	0	0	0	0	0	0	0	0
		Species:	RA	14.5	0	0	57	3	8	1	73	64	193	170	19
		Species:	RC	2.5	23	1	16	1	2	1	25	23	51	49	14
		Species:	SS	2.1	191	4	21	42	145	35	890	846	3,063	2,910	712
		Species:	WH	1.8	486	9	23	14	65	10	302	287	1,386	1,317	210
25	(467)	########		1.9	708	15	22	63	230	49	1,348	1,276	4,881	4,623	986
30															
		Species:	AC	5.5	4	1	33	8	27	5	116	110	376	357	63
		Species:	LP	4.5	6	1	28	0	0	0	0	0	0	0	0
		Species:	MH	0.0	0	0	4	0	0	0	0	0	0	0	0
		Species:	RA	14.8	0	1	57	9	25	3	140	123	369	325	36
		Species:	RC	3.3	20	1	24	4	7	2	49	47	102	97	28
		Species:	SS	3.8	138	11	37	125	429	105	1,719	1,633	5,910	5,615	1,372
		Species:	WH	2.5	459	15	30	39	181	29	541	514	2,501	2,376	381

Species - Summary Report by Age Class

Thorne Bay Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
30	(284)	########		2.9	628	30	31	185	669	143	2,567	2,428	9,258	8,770	1,879
35															
	Species:		AC	5.3	2	0	32	5	15	3	84	80	271	257	45
	Species:		LP	4.4	3	0	28	0	0	0	0	0	0	0	0
	Species:		RA	6.5	11	3	41	15	47	5	288	254	917	807	89
	Species:		RC	3.7	50	4	30	31	78	20	553	526	1,399	1,329	335
	Species:		SS	5.5	221	37	43	667	2,266	680	11,939	11,342	40,558	38,531	11,565
	Species:		WH	3.2	609	34	38	366	1,391	283	6,552	6,222	24,921	23,661	4,818
35	(331)	########		4.0	897	77	39	1,083	3,798	991	19,416	18,422	68,066	64,585	16,851
40															
	Species:		MH	5.3	0	0	30	1	1	0	15	14	34	32	8
	Species:		RA	6.0	25	5	40	20	71	8	519	457	1,829	1,609	177
	Species:		RC	3.8	88	7	32	67	171	43	1,585	1,506	4,072	3,868	979
	Species:		SS	6.2	321	68	46	1,331	4,510	1,383	31,717	30,131	107,447	102,075	31,302
	Species:		WH	3.6	779	57	42	783	2,930	613	18,647	17,715	69,817	66,325	13,866
40	(372)	########		4.5	1,214	136	43	2,201	7,684	2,047	52,483	49,822	183,199	173,910	46,332
45															
	Species:		AC	2.7	8	0	20	3	9	1	74	70	220	209	33
	Species:		BC	1.6	0	0	13	0	0	0	0	0	0	0	0
	Species:		LP	4.6	1	0	25	1	2	0	13	13	42	40	10

Species - Summary Report by Age Class

Thorne Bay Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	MH	3.0	6	0	18	3	8	2	71	68	203	193	52
		Species:	RA	6.5	23	5	45	39	133	19	1,042	917	3,525	3,102	436
		Species:	RC	4.2	113	11	34	115	327	97	2,822	2,681	8,040	7,638	2,273
		Species:	SA	0.9	4	0	9	0	0	0	0	0	0	0	0
		Species:	SS	6.9	335	87	53	1,848	6,402	2,045	45,494	43,219	157,567	149,689	47,803
		Species:	WH	4.0	803	71	43	1,024	3,838	831	25,209	23,949	94,471	89,747	19,424
45	(375)	########		5.0	1,293	175	45	3,033	10,719	2,995	74,726	70,916	264,068	250,617	70,031
50															
		Species:	AC	6.8	2	0	36	5	15	4	50	48	142	135	35
		Species:	LP	0.4	0	0	46	0	0	0	0	0	0	0	0
		Species:	MH	8.4	0	0	38	1	5	1	12	11	47	45	11
		Species:	RA	6.1	13	3	42	29	102	17	297	261	1,059	932	154
		Species:	RC	5.6	75	13	35	124	373	101	1,194	1,134	3,600	3,420	928
		Species:	SA	4.6	9	1	26	0	0	0	0	0	0	0	0
		Species:	SS	9.4	224	109	60	2,502	9,097	2,960	24,138	22,931	87,752	83,364	27,131
		Species:	WH	6.0	478	94	50	1,536	6,019	1,341	14,815	14,075	58,063	55,159	12,286
50	(136)	9,164.4		7.1	801	220	51	4,197	15,610	4,424	40,506	38,460	150,662	143,055	40,544
55															
		Species:	AC	8.5	0	0	43	2	6	1	13	13	36	34	4
		Species:	LP	9.4	1	1	70	10	31	7	56	54	178	169	37
		Species:	MH	11.7	0	0	58	4	12	3	24	22	68	65	14

Species - Summary Report by Age Class

Thorne Bay Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RA	7.0	13	4	49	40	137	28	248	218	844	743	150
		Species:	RC	6.4	21	5	39	49	165	48	282	268	945	898	263
		Species:	SS	13.1	195	181	78	5,059	19,184	7,058	28,936	27,489	109,732	104,245	38,354
		Species:	WH	7.6	248	77	57	1,456	5,751	1,413	8,328	7,912	32,898	31,253	7,678
55	(71)	5,434.0		10.1	479	268	65	6,621	25,286	8,557	37,888	35,976	144,701	137,407	46,500
60															
		Species:	RC	10.1	3	2	52	29	86	24	29	27	84	80	23
		Species:	SS	13.2	191	183	86	5,603	22,693	7,984	5,476	5,202	22,179	21,070	7,414
		Species:	WH	8.4	278	108	74	2,573	10,802	2,858	2,514	2,389	10,558	10,030	2,654
60	(20)	928.5		10.6	473	292	79	8,205	33,581	10,867	8,020	7,619	32,821	31,180	10,090
65															
		Species:	AC	8.1	2	1	63	7	28	4	7	6	28	27	4
		Species:	RC	14.4	9	10	83	299	1,298	566	298	283	1,294	1,230	537
		Species:	SS	13.7	131	134	96	4,503	19,319	7,282	4,489	4,265	19,262	18,299	6,897
		Species:	WH	9.4	270	130	79	3,088	13,625	3,890	3,079	2,925	13,585	12,906	3,685
65	(32)	947.2		11.0	412	274	84	7,896	34,270	11,743	7,873	7,479	34,169	32,461	11,123
70															
		Species:	AC	6.4	0	0	65	0	1	0	0	0	0	0	0
		Species:	RC	9.4	11	5	51	100	423	148	26	25	109	104	36
		Species:	SS	14.6	97	112	103	4,208	19,109	7,520	1,088	1,034	4,940	4,693	1,847

Species - Summary Report by Age Class

Thorne Bay Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	8.3	347	131	67	2,851	12,508	3,485	737	700	3,234	3,072	856
70	(22)	245.6		10.0	454	249	76	7,159	32,041	11,153	1,851	1,758	8,284	7,869	2,739
75															
		Species:	AC	1.1	0	0	65	0	0	0	0	0	0	0	0
		Species:	RC	9.7	3	1	58	26	96	26	1	1	4	4	1
		Species:	SS	14.7	78	92	95	3,186	13,782	5,389	129	123	559	532	208
		Species:	WH	8.8	307	130	77	3,231	14,190	3,961	131	125	576	547	153
75	(15)	38.6		10.3	388	223	81	6,442	28,068	9,376	262	248	1,139	1,082	362
80															
		Species:	AC	7.0	55	14	65	268	1,152	206	7	7	30	28	5
		Species:	RC	16.6	10	15	96	478	1,867	769	12	12	48	46	19
		Species:	SS	16.7	77	117	109	4,373	19,611	8,005	113	107	505	480	196
		Species:	WH	11.9	241	186	96	5,790	26,141	8,655	149	142	673	639	212
80	(1)	24.5		12.6	383	333	95	10,908	48,772	17,635	281	267	1,256	1,193	431
90															
		Species:	RC	6.9	5	1	48	12	39	10	0	0	1	1	0
		Species:	SS	14.6	121	141	85	4,729	19,966	7,775	66	63	280	266	104
		Species:	WH	10.9	191	125	83	3,838	17,327	5,733	54	51	243	231	76
90	(5)	13.3		12.4	316	267	83	8,579	37,331	13,518	120	114	524	498	180

Species - Summary Report by Age Class

Thorne Bay Year-end 2013

Net of Buffers Acreage

Age				Per Acre							Total Stand (1,000s)				
Class	(#Stds)	Acres	Spp	Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
Sum:	2,935	#########									247,385	234,830	903,208	857,421	248,075

Species - Summary Report by Age Class

Wrangell Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
5															
		Species:	AC	9.4	1	1	52	19	88	25	36	34	163	155	44
		Species:	MH	0.8	0	0	15	0	0	0	0	0	0	0	0
		Species:	RA	8.0	15	5	52	63	226	35	125	110	453	398	62
		Species:	RC	3.0	91	4	16	108	479	221	209	190	930	843	389
		Species:	SS	2.7	1,204	47	20	1,201	4,643	1,675	2,225	2,114	8,603	8,173	2,948
		Species:	WH	2.6	1,310	48	25	1,046	4,274	1,296	1,943	1,841	7,943	7,524	2,281
		Species:	YC	0.0	3	0	1	0	0	0	0	0	0	0	0
5	(41)	1,760.2		2.7	2,623	106	23	2,437	9,711	3,252	4,538	4,289	18,092	17,093	5,724
10															
		Species:	AC	5.9	14	3	57	73	316	88	56	53	245	233	65
		Species:	MH	3.2	31	2	22	38	138	29	30	28	107	101	22
		Species:	RC	8.7	14	6	41	225	1,139	539	174	166	884	840	397
		Species:	SS	2.7	242	10	26	341	1,519	624	264	251	1,179	1,120	460
		Species:	WH	3.4	441	27	32	902	4,363	1,610	700	665	3,385	3,216	1,187
10	(56)	737.0		3.4	742	47	30	1,578	7,476	2,890	1,224	1,163	5,799	5,509	2,130
15															
		Species:	AC	1.4	9	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	34	0	15	0	0	0	0	0	0	0	0
		Species:	RC	1.5	14	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	266	1	19	2	6	1	2	2	5	5	1

Species - Summary Report by Age Class

Wrangell Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	1.1	472	3	19	0	0	0	0	0	0	0	0
15	(41)	843.1		1.0	795	4	19	2	6	1	2	2	5	5	1
20															
		Species:	AC	1.4	9	0	11	0	0	0	0	0	0	0	0
		Species:	MH	0.8	34	0	15	0	0	0	0	0	0	0	0
		Species:	RC	1.5	14	0	9	0	0	0	0	0	0	0	0
		Species:	SS	0.8	266	1	19	2	6	1	11	10	31	30	7
		Species:	WH	1.1	472	3	19	0	0	0	0	0	0	0	0
20	(182)	5,382.2		1.0	795	4	19	2	6	1	11	10	31	30	7
25															
		Species:	AC	2.3	8	0	14	4	20	5	23	22	101	96	26
		Species:	MH	0.8	28	0	15	0	0	0	0	0	0	0	0
		Species:	RC	1.9	14	0	10	0	0	0	0	0	0	0	0
		Species:	SS	2.1	241	6	21	77	248	60	397	377	1,280	1,216	295
		Species:	WH	1.6	428	6	21	39	115	26	200	190	594	564	126
25	(127)	4,899.5		1.8	719	13	20	120	383	91	619	588	1,975	1,877	447
30															
		Species:	AC	11.4	1	1	48	25	110	30	109	103	479	456	123
		Species:	RC	3.1	15	1	15	0	0	0	0	0	0	0	0
		Species:	SS	6.6	125	29	33	422	1,367	331	1,837	1,745	5,945	5,648	1,369

Species - Summary Report by Age Class

Wrangell Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	4.2	228	22	32	217	646	145	945	898	2,810	2,669	597
30	(143)	4,131.4		5.1	370	53	32	665	2,123	506	2,891	2,746	9,234	8,773	2,089
35															
		Species:	AC	11.4	1	1	48	18	82	22	94	89	415	395	107
		Species:	MH	8.1	2	1	43	11	32	7	55	52	164	156	36
		Species:	RA	9.2	4	2	54	22	79	12	119	105	436	384	59
		Species:	RC	4.8	16	2	21	20	46	13	103	97	236	224	64
		Species:	SS	6.3	141	30	38	474	1,532	406	2,415	2,294	7,809	7,418	1,965
		Species:	WH	3.8	271	22	35	247	780	174	1,257	1,194	3,977	3,776	844
35	(121)	4,840.8		4.9	435	57	36	792	2,552	635	4,044	3,833	13,038	12,352	3,074
40															
		Species:	MH	7.7	7	2	42	36	107	24	254	242	752	714	163
		Species:	RA	8.9	12	5	53	56	205	30	424	373	1,554	1,368	200
		Species:	RC	7.9	20	7	33	108	247	71	755	717	1,738	1,650	470
		Species:	SS	4.9	188	25	45	471	1,504	463	3,309	3,141	10,574	10,038	3,088
		Species:	WH	2.9	453	21	40	287	1,029	231	2,019	1,915	7,237	6,863	1,542
40	(98)	6,672.2		4.0	682	60	41	957	3,092	819	6,762	6,388	21,856	20,633	5,464
45															
		Species:	AC	2.9	0	0	23	0	1	0	1	1	2	2	0
		Species:	MH	7.5	7	2	41	34	100	23	125	119	371	352	81

Species - Summary Report by Age Class

Wrangell Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	RA	7.5	12	4	49	45	166	24	182	160	666	586	85
		Species:	RC	6.9	27	7	32	101	237	67	375	356	879	834	238
		Species:	SS	5.4	207	33	45	671	2,294	731	2,490	2,364	8,513	8,083	2,576
		Species:	WH	3.3	503	31	40	465	1,722	407	1,725	1,637	6,393	6,067	1,434
45	(118)	3,524.0		4.3	757	76	42	1,316	4,519	1,252	4,898	4,637	16,823	15,924	4,414
50															
		Species:	RA	7.8	34	11	48	143	518	84	139	122	503	442	72
		Species:	RC	4.5	61	7	34	48	136	38	43	41	122	116	33
		Species:	SS	8.1	263	94	51	2,157	7,679	2,602	1,937	1,840	6,898	6,553	2,221
		Species:	WH	5.1	578	83	46	1,459	5,521	1,359	1,311	1,245	4,959	4,711	1,160
50	(32)	853.4		6.2	935	195	47	3,807	13,854	4,084	3,430	3,249	12,483	11,823	3,485
55															
		Species:	RA	7.4	28	8	50	104	380	61	56	50	206	181	29
		Species:	RC	4.5	21	2	34	17	46	13	8	8	23	22	6
		Species:	SS	9.4	262	127	58	3,315	12,552	4,409	1,666	1,583	6,310	5,994	2,105
		Species:	WH	6.0	457	90	50	1,848	7,234	1,930	929	882	3,636	3,454	922
55	(15)	477.5		7.4	768	227	53	5,283	20,213	6,413	2,660	2,523	10,175	9,652	3,062
60															
		Species:	RA	11.2	1	0	72	8	29	3	5	4	18	16	2
		Species:	SS	12.2	188	153	71	4,472	17,598	6,432	2,625	2,493	10,329	9,812	3,586

Species - Summary Report by Age Class

Wrangell Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	WH	8.2	304	111	59	2,555	10,389	2,956	1,500	1,425	6,097	5,792	1,648
60	(25)	557.6		9.9	492	265	64	7,035	28,016	9,391	4,129	3,922	16,444	15,621	5,236
65															
		Species:	AC	8.9	1	1	87	16	71	20	9	9	41	39	11
		Species:	MH	11.2	1	0	63	8	31	7	5	5	18	17	4
		Species:	RA	11.3	1	1	72	10	38	4	6	6	24	21	2
		Species:	RC	25.4	0	1	120	50	255	120	29	28	148	141	67
		Species:	SS	12.0	186	147	71	4,294	16,989	6,238	2,504	2,378	9,906	9,411	3,455
		Species:	WH	8.3	305	114	61	2,713	11,230	3,288	1,582	1,503	6,548	6,221	1,821
65	(18)	553.9		9.9	494	264	65	7,091	28,613	9,677	4,135	3,928	16,685	15,850	5,360
70															
		Species:	AC	9.0	8	3	87	93	407	113	4	3	16	15	4
		Species:	MH	11.3	3	2	63	49	177	38	2	2	7	7	1
		Species:	RA	11.3	4	3	72	52	191	21	2	2	8	7	1
		Species:	RC	25.7	2	7	120	289	1,466	694	11	11	57	55	26
		Species:	SS	12.9	115	104	82	3,370	14,015	5,291	132	125	549	521	197
		Species:	WH	8.6	362	145	64	3,895	17,214	5,287	152	145	674	640	197
70	(6)	37.2		9.9	493	264	69	7,748	33,470	11,444	303	288	1,311	1,245	426
75															
		Species:	AC	9.0	2	1	87	22	95	26	0	0	2	2	1

Species - Summary Report by Age Class

Wrangell Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
		Species:	MH	11.2	1	0	63	11	41	9	0	0	1	1	0
		Species:	RA	11.3	4	3	72	60	222	24	1	1	5	4	0
		Species:	RC	25.5	0	2	120	68	343	162	1	1	7	7	3
		Species:	SS	12.6	126	110	80	3,512	14,477	5,405	73	69	301	286	107
		Species:	WH	8.1	387	139	59	3,448	14,793	4,221	72	68	308	292	83
75	(3)	19.8		9.5	521	255	65	7,120	29,971	9,847	148	141	624	592	195
80															
		Species:	AC	9.0	43	19	87	534	2,330	647	27	25	116	110	31
		Species:	MH	11.3	17	12	63	280	1,014	215	14	13	50	48	10
		Species:	RC	25.7	12	42	120	1,655	8,395	3,972	82	78	417	396	187
		Species:	SS	16.3	45	66	112	2,497	11,162	4,591	124	118	554	526	216
		Species:	WH	12.8	203	183	102	6,650	32,158	11,866	330	313	1,596	1,516	559
80	(3)	47.1		13.5	321	322	101	11,617	55,059	21,292	576	548	2,732	2,595	1,004
90															
		Species:	AC	9.0	38	17	87	462	2,014	560	107	102	466	443	123
		Species:	MH	11.3	15	10	63	242	877	186	56	53	203	193	41
		Species:	RA	11.3	1	0	72	8	31	3	2	2	8	7	1
		Species:	RC	25.7	10	36	120	1,431	7,257	3,434	331	315	1,681	1,597	756
		Species:	SS	15.2	57	72	103	2,641	11,631	4,706	612	581	2,694	2,559	1,035
		Species:	WH	11.9	229	177	94	6,198	29,704	10,786	1,435	1,364	6,879	6,535	2,373

Species - Summary Report by Age Class

Wrangell Year-end 2013

Net of Buffers Acreage

Age Class	(#Stds)	Acres	Spp	Per Acre Dbh	Trees	Basal	Htt	NetCub	NetBrd	GrsVal	Total Stand (1,000s) GrsCub	NetCub	GrsBrd	NetBrd	GrsVal
90	(17)	220.0		12.8	350	312	94	10,982	51,515	19,675	2,543	2,416	11,931	11,334	4,329
100															
	Species:		AC	9.0	40	18	87	492	2,146	596	8	7	33	31	9
	Species:		MH	11.3	16	11	63	258	934	198	4	4	14	14	3
	Species:		RA	11.2	0	0	72	5	18	2	0	0	0	0	0
	Species:		RC	25.7	11	39	120	1,525	7,732	3,659	23	22	118	112	53
	Species:		SS	15.6	52	69	106	2,581	11,435	4,658	40	38	175	166	68
	Species:		WH	12.3	219	179	97	6,386	30,728	11,236	98	93	471	447	163
100	(3)	14.5		13.1	338	316	97	11,247	52,993	20,350	172	164	811	771	296
Sum:	1,049	35,571.3									43,088	40,835	160,050	151,677	46,741

APPENDIX E: TONGASS TIMBER REFORM ACT (TTRA), SECTION 101

Public Law 101-626
101st Congress

An Act

Nov. 28, 1990
[H.R. 987]

To amend the Alaska National Interest Lands Conservation Act, to protect certain lands in the Tongass National Forest in perpetuity, to modify certain long-term timber contracts, to provide for protection of riparian habitat, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Tongass Timber Reform Act.
16 USC 539d note.

SECTION 1. SHORT TITLE AND DEFINITION.

(a) SHORT TITLE.—This Act may be cited as the "Tongass Timber Reform Act".

TITLE I—FOREST MANAGEMENT PROVISIONS

SEC. 101. TO REQUIRE ANNUAL APPROPRIATIONS FOR TIMBER MANAGEMENT ON THE TONGASS NATIONAL FOREST.

The Alaska National Interest Lands Conservation Act (Public Law 96-487, hereinafter referred to as "ANILCA") is hereby amended by deleting section 705(a) (16 U.S.C. 539d(a)) in its entirety and inserting in lieu thereof the following:

"SEC. 705. (a) Subject to appropriations, other applicable law, and the requirements of the National Forest Management Act of 1976 (Public Law 94-588), except as provided in subsection (d) of this section, the Secretary shall, to the extent consistent with providing for the multiple use and sustained yield of all renewable forest resources, seek to provide a supply of timber from the Tongass National Forest which (1) meets the annual market demand for timber from such forest and (2) meets the market demand from such forest for each planning cycle.".

SEC. 102. IDENTIFICATION OF LANDS UNSUITABLE FOR TIMBER PRODUCTION.

ANILCA is further amended by deleting section 705(d) (16 U.S.C. 539d(d)) in its entirety and inserting in lieu thereof:

"(d) All provisions of section 6(k) of the National Forest Management Act of 1976 (16 U.S.C. 1604(k)) shall apply to the Tongass National Forest except that the Secretary need not consider economic factors in the identification of lands not suited for timber production.".

SEC. 103. FISHERIES PROTECTION.

(a) Section 705 (16 U.S.C. 539d) of ANILCA is amended by adding at the end thereof the following new subsection:

"(e) In order to assure protection of riparian habitat, the Secretary shall maintain a buffer zone of no less than one hundred feet in width on each side of all Class I streams in the Tongass National Forest, and on those Class II streams which flow directly into a Class I stream, within which commercial timber harvesting shall be prohibited, except where independent national forest timber sales

AUTHENTICATED U.S. GOVERNMENT INFORMATION GPO

APPENDIX F: ANILCA SECTION 705(a)

NATIONAL FOREST TIMBER UTILIZATION PROGRAM

16 USC 539d.

SEC. 705. (a) The Congress authorizes and directs that the Secretary of the Treasury shall make available to the Secretary of Agriculture the sum of at least $40,000,000 annually or as much as the Secretary of Agriculture finds is necessary to maintain the timber supply from the Tongass National Forest to dependent industry at a rate of four billion five hundred million foot board measure per decade. Such sums will be drawn from receipts from oil, gas, timber, coal, and other natural resources collected by the Secretary of Agriculture and the Secretary of the Interior notwithstanding any other law providing for the distribution of such receipts: *Provided*, That such funds shall not be subject to deferral or rescission under the Budget Impoundment and Control Act of 1974, and such funds shall not be subject to annual appropriation.

31 USC 1401 note.

Forest materials Purchasers, loan program.

(b)(1) The Secretary is authorized and directed to establish a special program of insured or guaranteed loans to purchasers of national forest materials in Alaska to assist such purchasers in the acquisition of equipment and the implementation of new technologies which lead to the utilization of wood products which might otherwise not be utilized. The Secretary is authorized to promulgate such regulations as he deems appropriate to define eligibility requirements for the participation in the loan program and the terms and conditions applicable to loans made under the program. Except as otherwise provided in this section or regulations promulgated specifically for this loan program, such program shall be carried out in a manner which is consistent with other authorities available to the Secretary.

Appropriation authorization.

(2) To carry out the special loan program established by this section, there are hereby authorized beginning after the fiscal year 1980 to be appropriated $5,000,000 from National Forest Fund receipts, to be deposited in a special fund in the Treasury of the United States to remain available until expended. Repayments of principal and interest and other recoveries on loans authorized by this section shall be credited to this fund and shall remain available until expended in order to carry out the purposes of this section.

Study, transmittal to Congress.

(c) Within three years after the date of enactment of this Act, the Secretary shall prepare and transmit to the Senate and House of Representatives a study of opportunities (consistent with the laws and regulations applicable to the management of the National Forest System) to increase timber yields on national forest lands in Alaska.

16 USC 1604.

(d) The provisions of this section shall apply notwithstanding the provisions of section 6(k) of the National Forest Management Act of 1976 (90 Stat. 2949).

REPORTS

Transmittal to congressional Committees. 16 USC 539e.

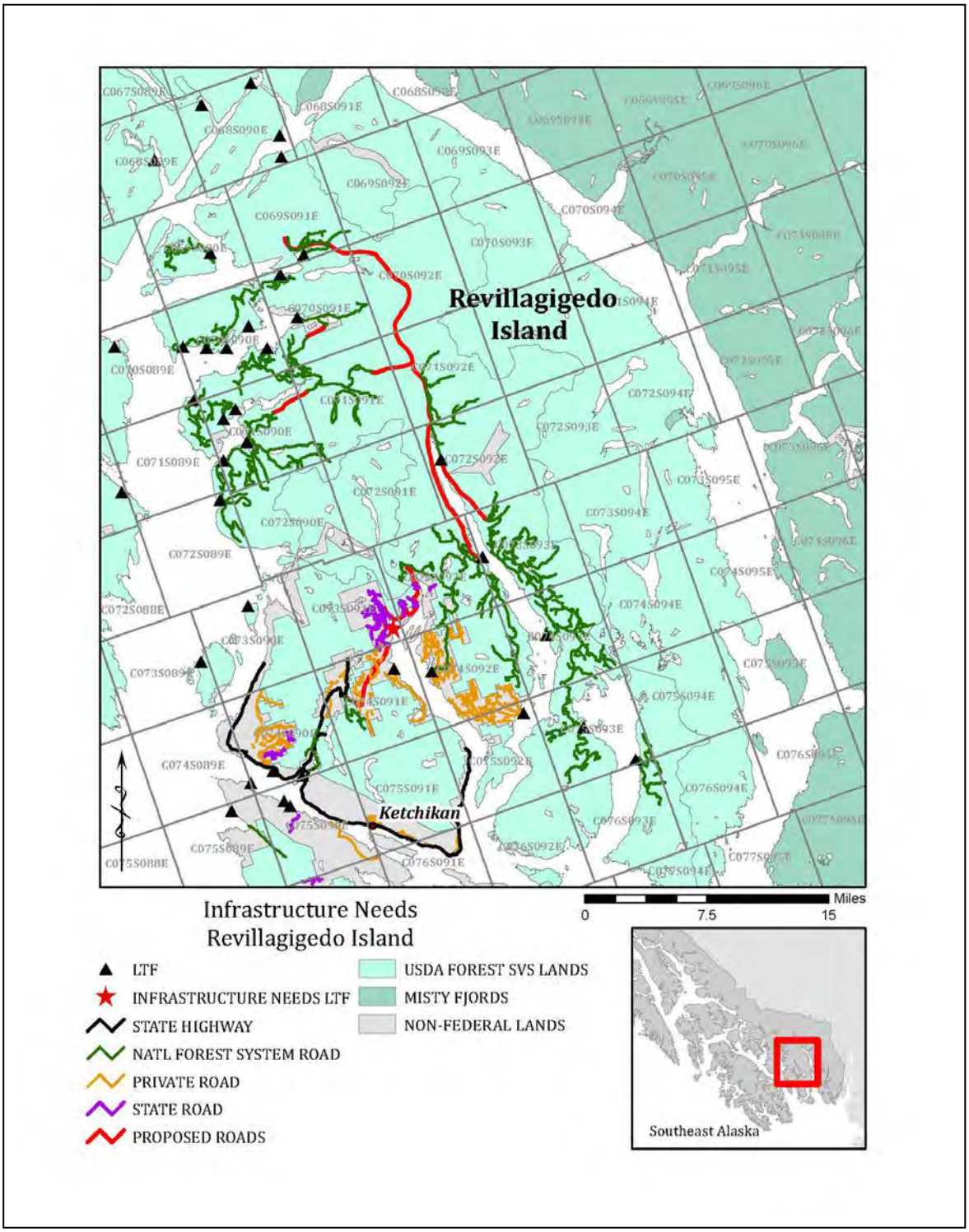
SEC. 706. (a) The Secretary is directed to monitor timber supply and demand in southeastern Alaska and report annually thereon to the Committee on Energy and Natural Resources of the Senate and the Committee on Interior and Insular Affairs of the House of Representatives. If, at any time after the date of enactment of this Act, the Secretary finds that the available land base in the Tongass National Forest is inadequate to maintain the timber supply from the Tongass National Forest to dependent industry at the rate of four billion five hundred million foot board measure per decade, he shall include such information in his report.

Review and report to Congress.

(b) Within five years from the date of enactment of this Act and every two years thereafter, the Secretary shall review and report to Congress on the status of the Tongass National Forest in southeast-

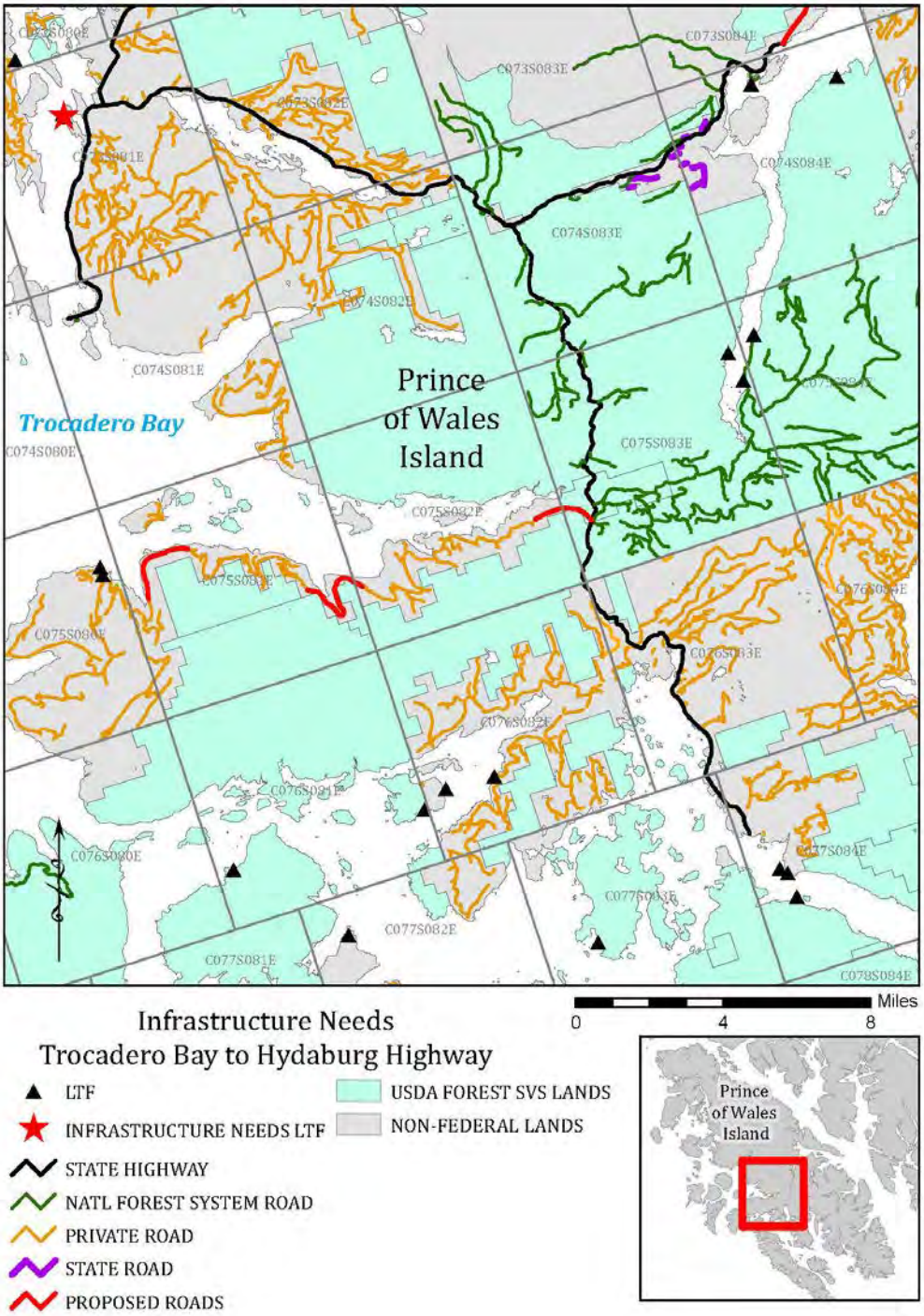
APPENDIX G: INFRASTRUCTURE NEEDS MAPS

Map 1. Revillagigedo Island



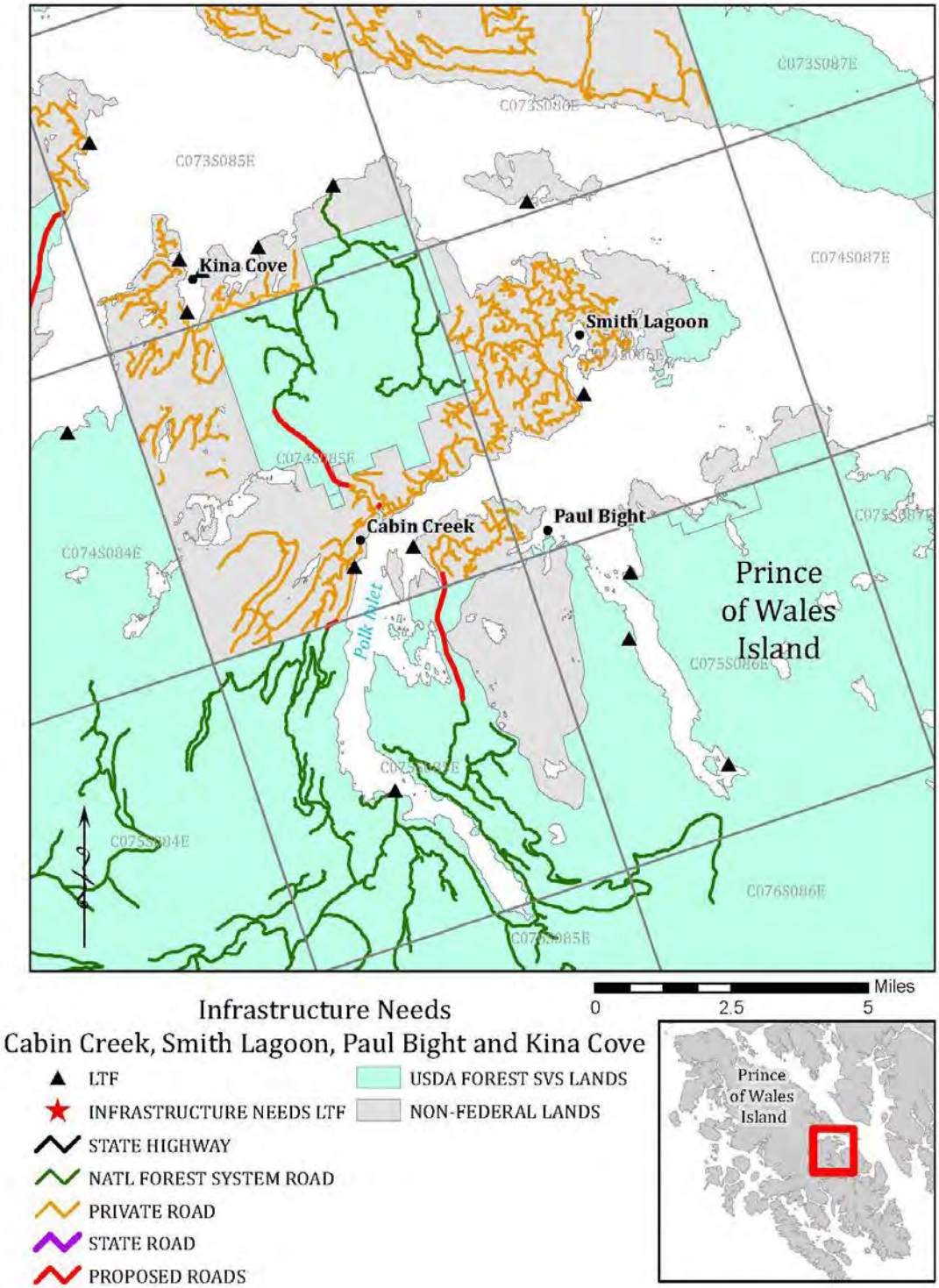
Map Developed by Alaska Mental Health Trust Land Office

Map 2. Prince of Wales Island - Trocadero Bay



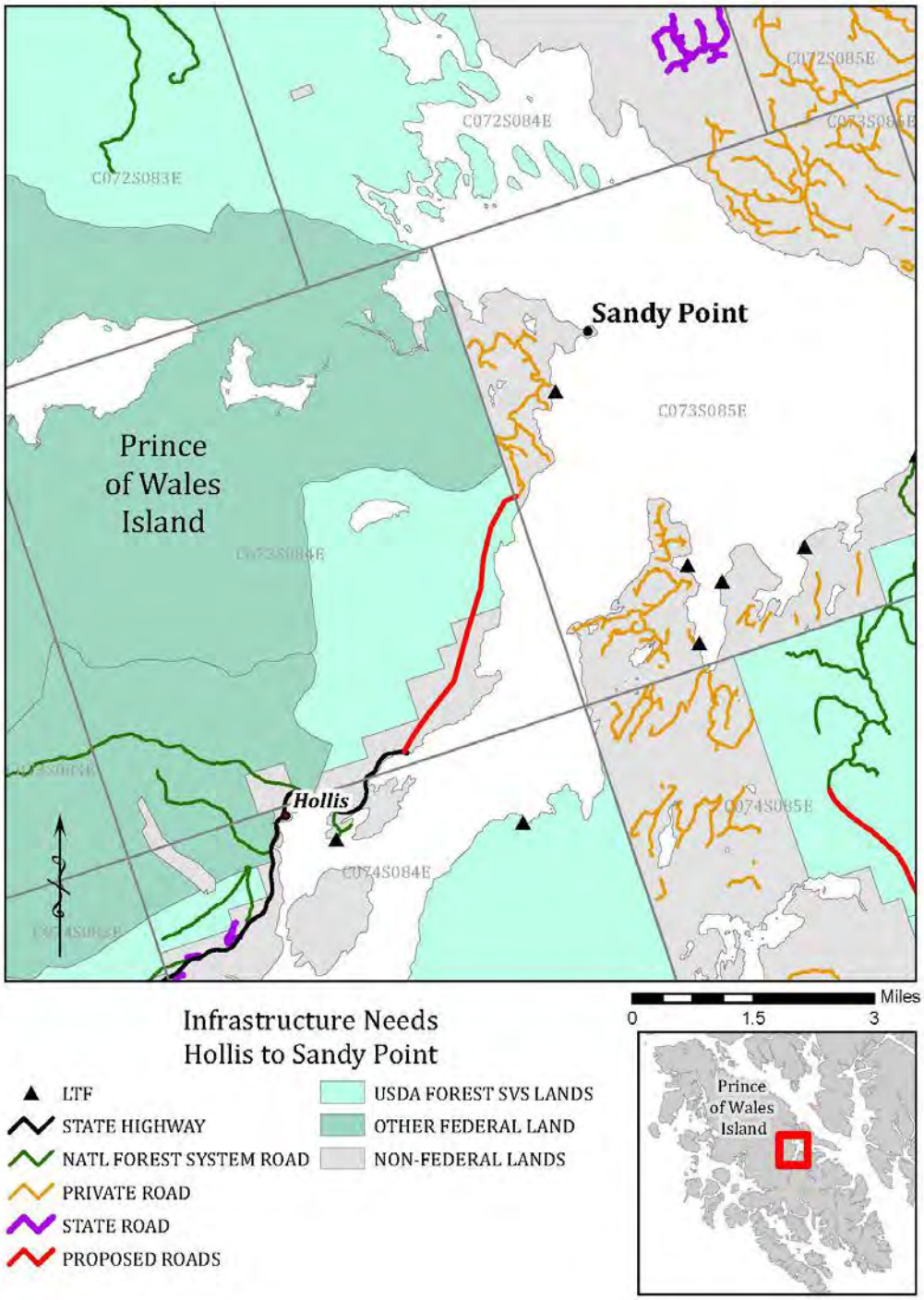
Map Developed by Alaska Mental Health Trust Land Office

Map 3. Prince of Wales of Island – Cabin Creek



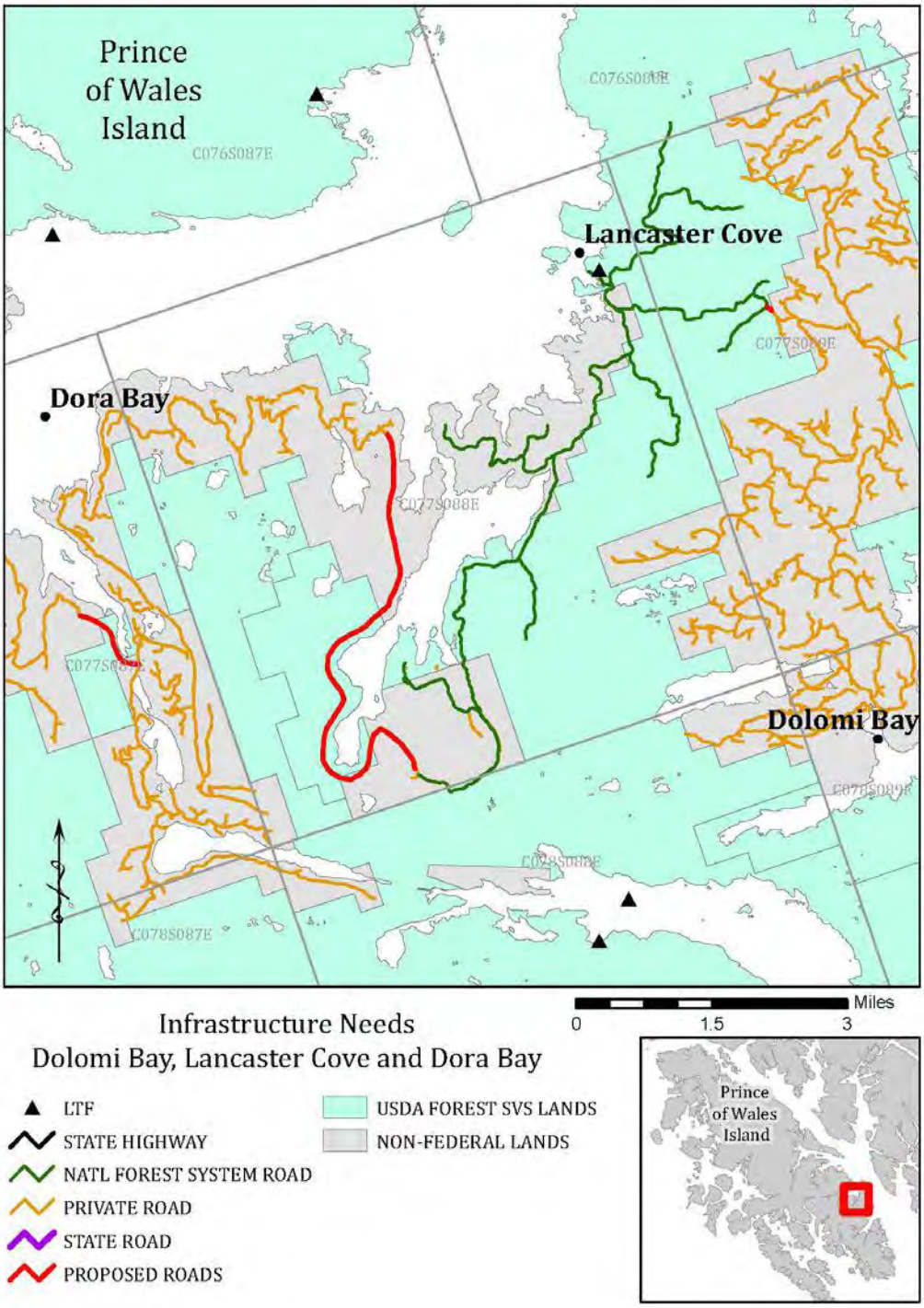
Map Developed by Alaska Mental Health Trust Land Office

Map 4. Prince of Wales of Island – Sandy Point



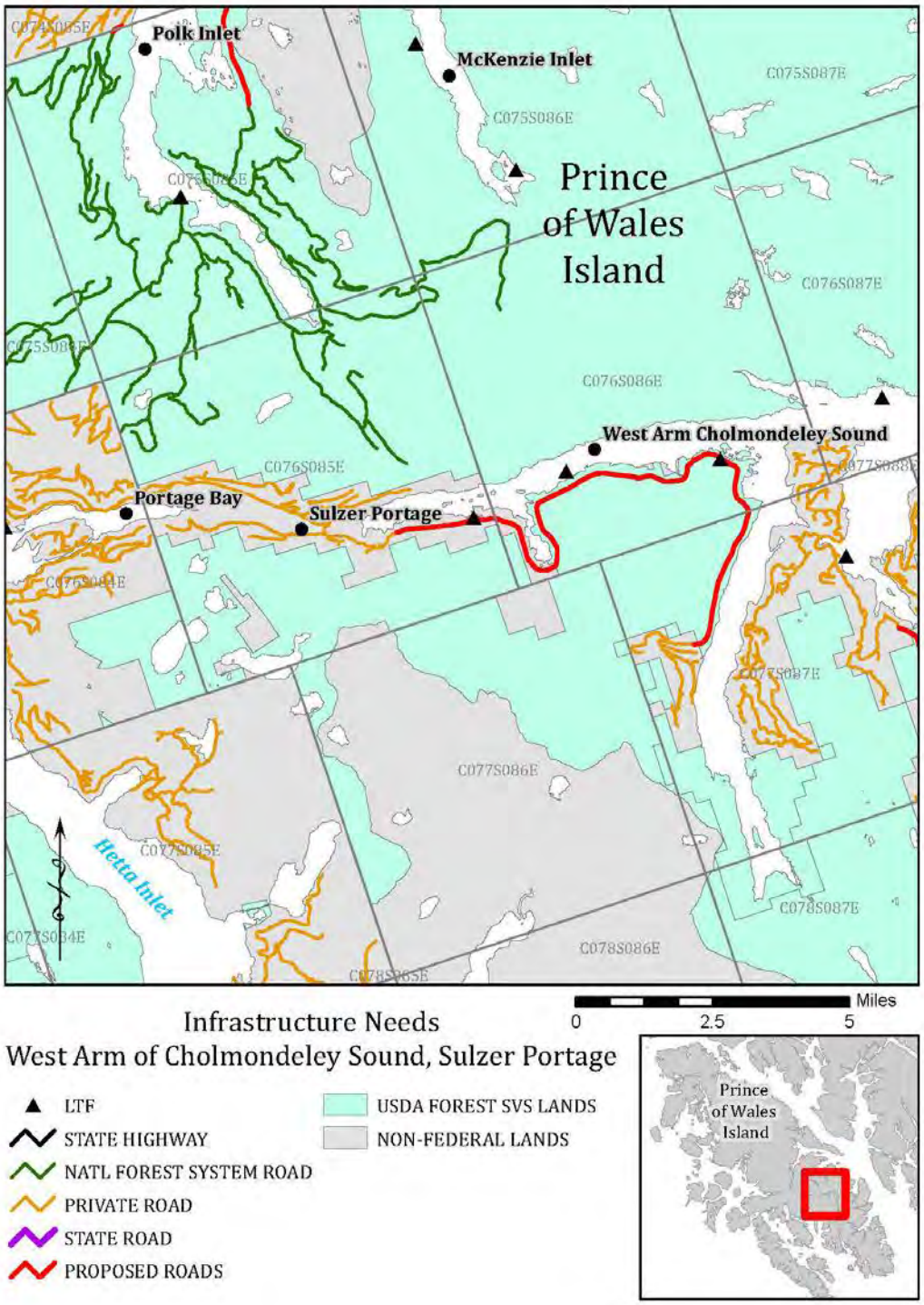
Map Developed by Alaska Mental Health Trust Land Office

Map 5. Prince of Wales of Island – Dolomi Bay



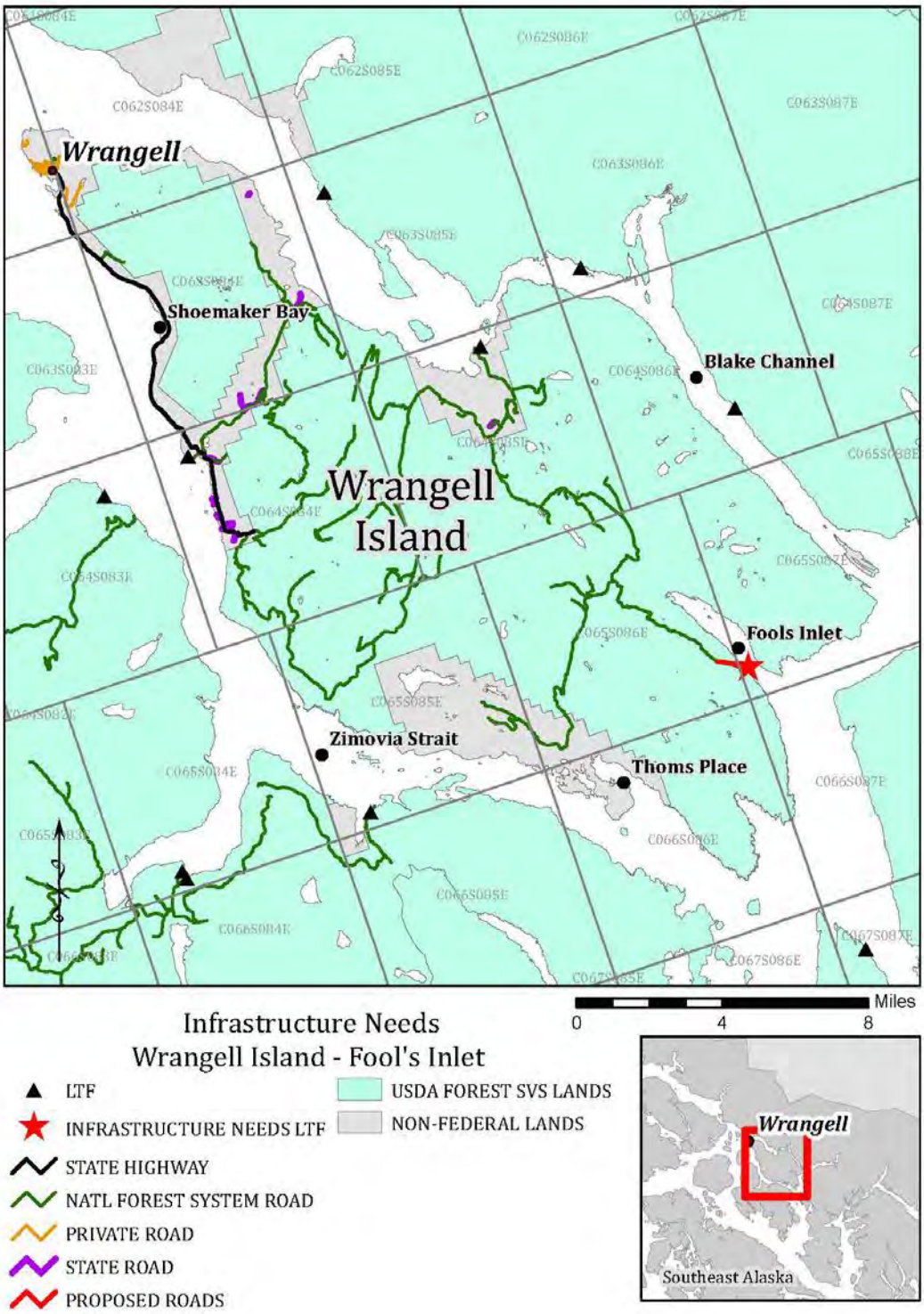
Map Developed by Alaska Mental Health Trust Land Office

Map 6. Prince of Wales of Island – West Arm of Cholmondeley Sound



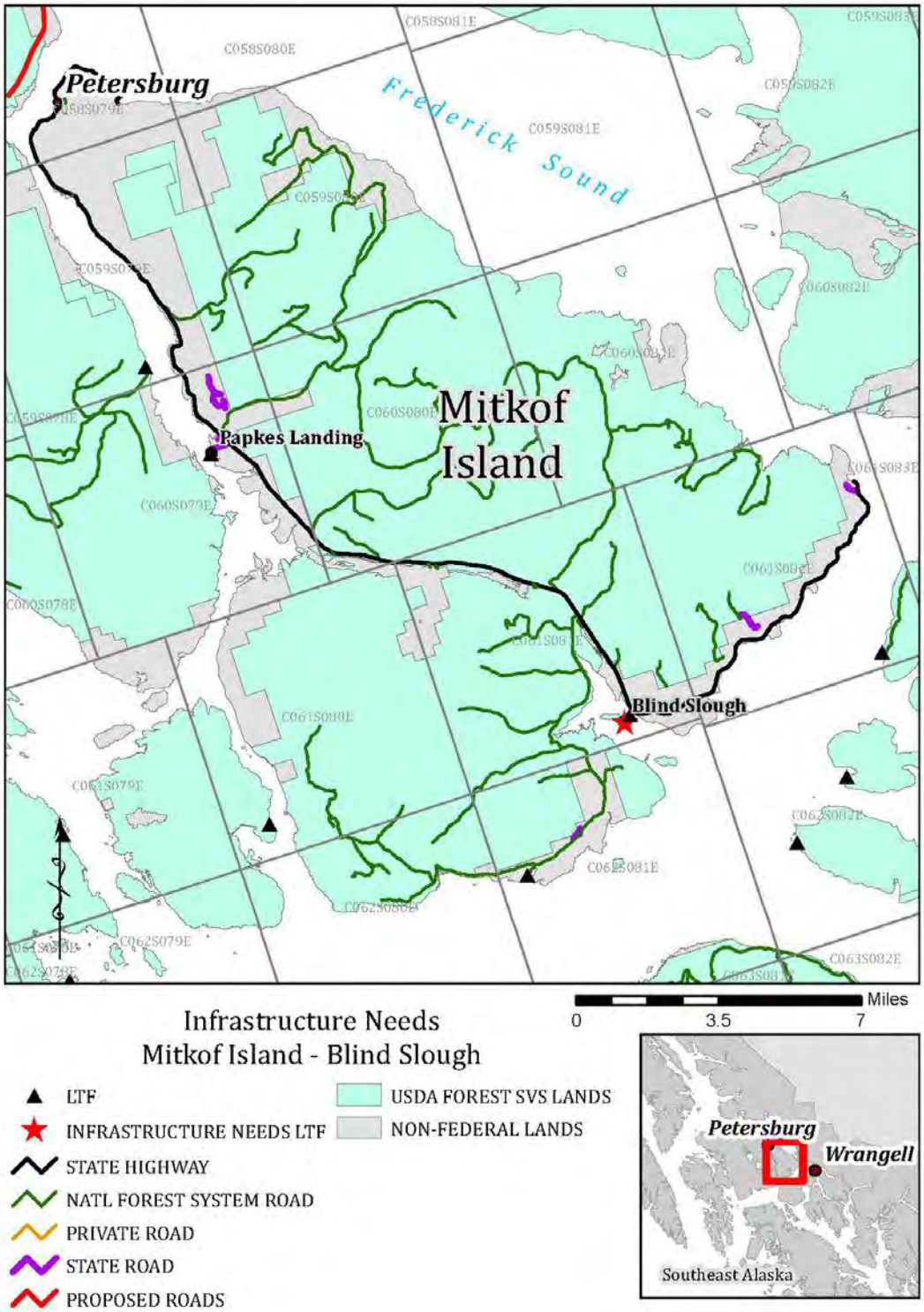
Map Developed by Alaska Mental Health Trust Land Office

Map 7. Wrangell Island



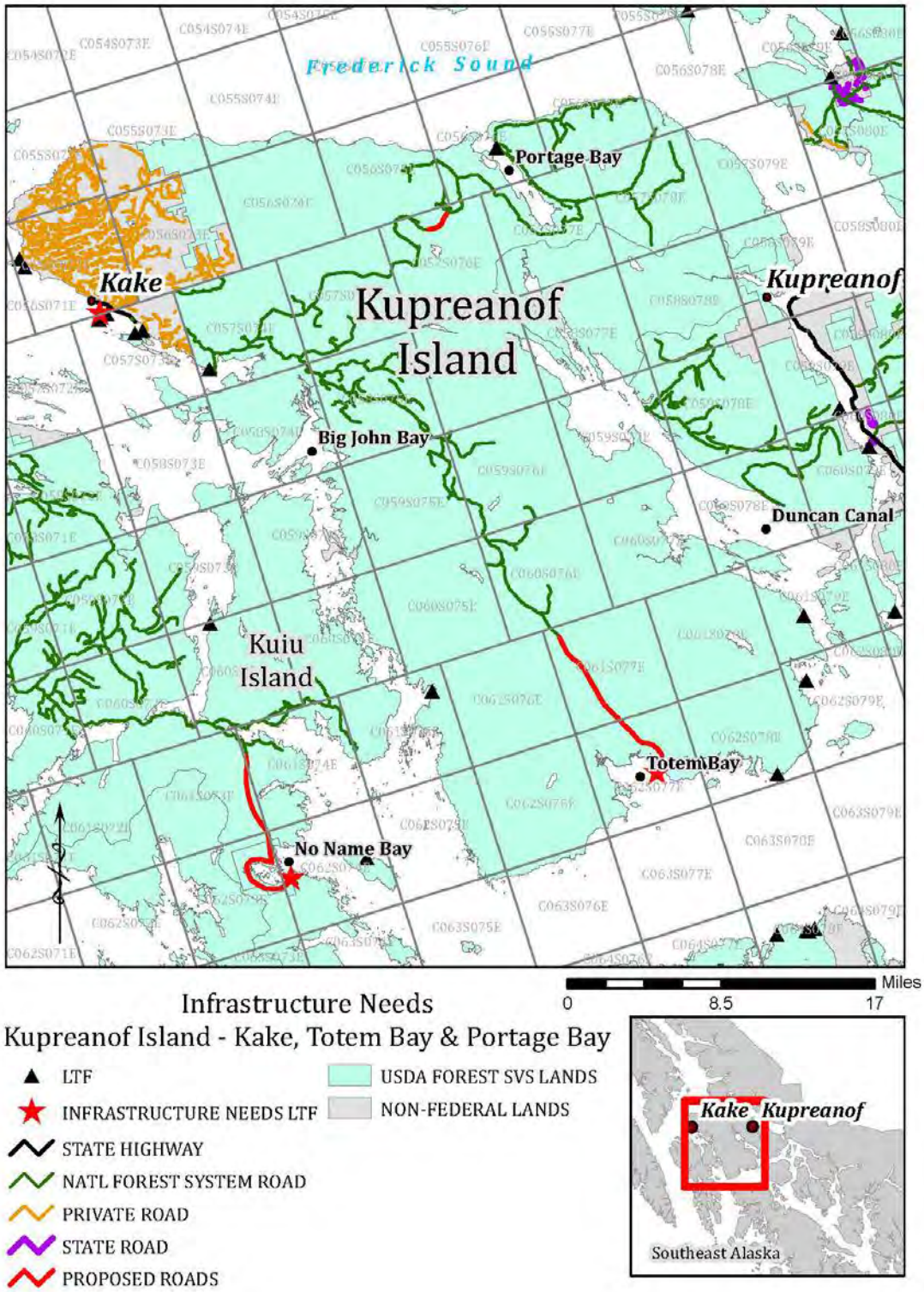
Map Developed by Alaska Mental Health Trust Land Office

Map 8. Mitkof Island



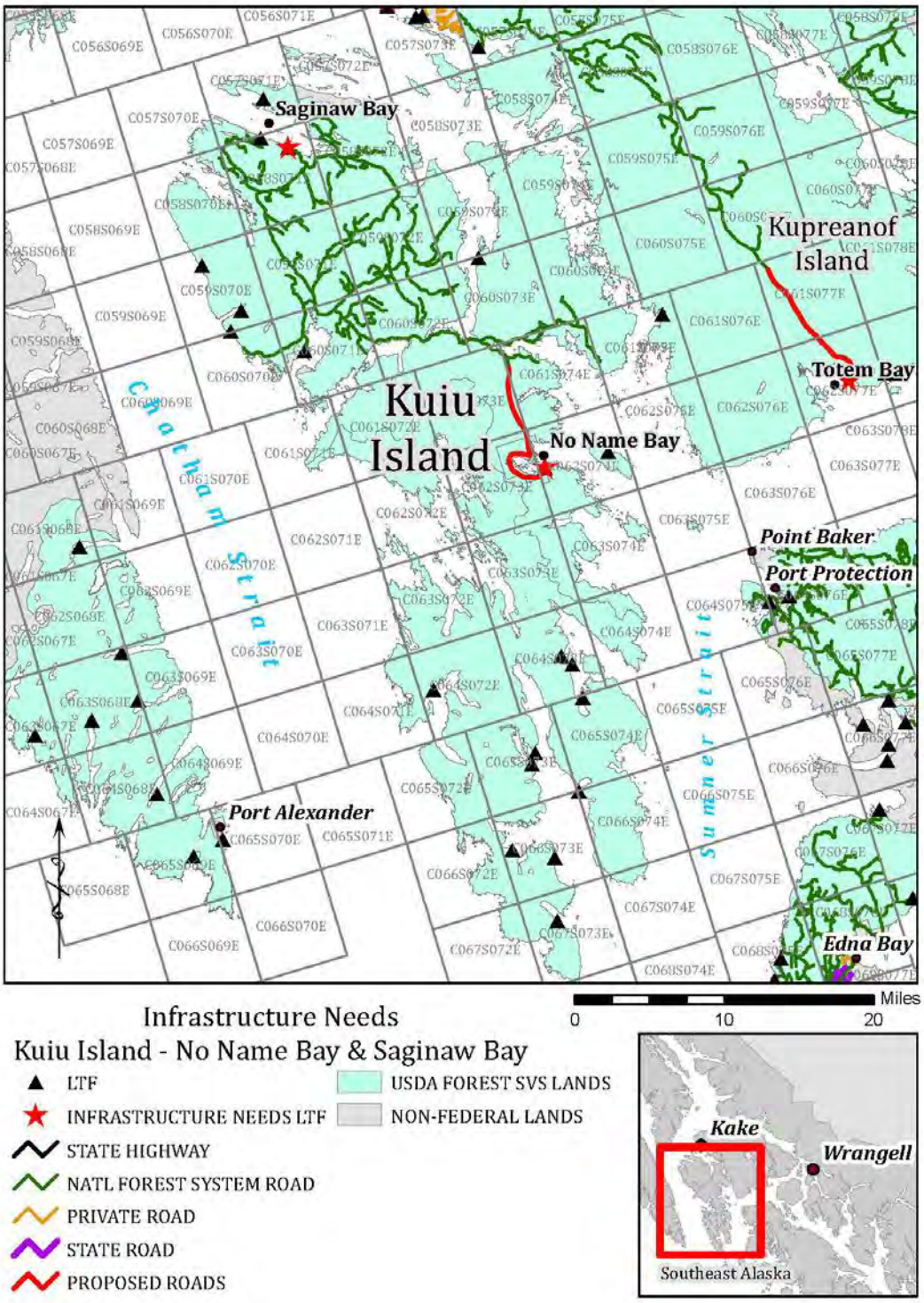
Map Developed by Alaska Mental Health Trust Land Office

Map 9. Kupreanof Island



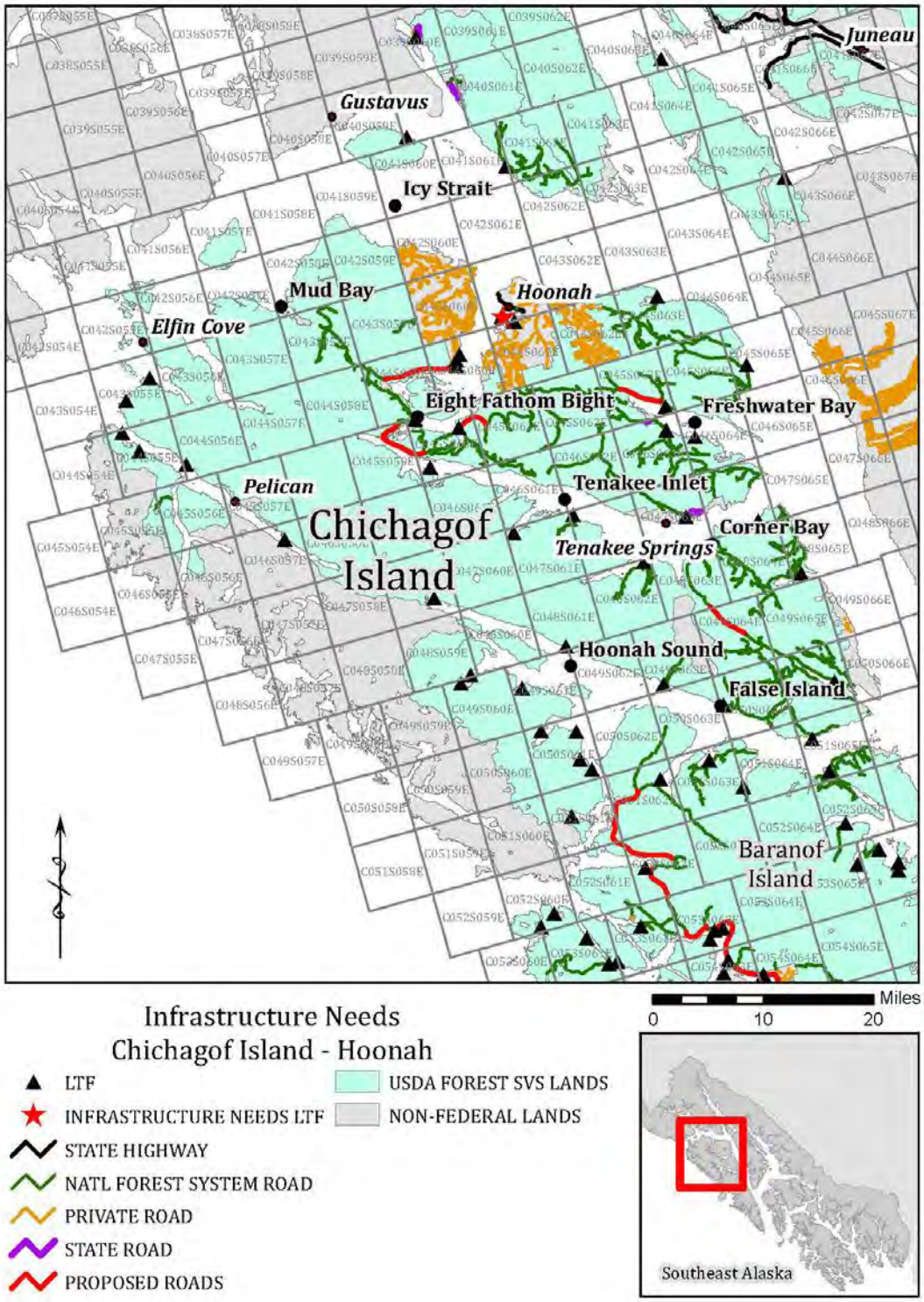
Map Developed by Alaska Mental Health Trust Land Office

Map 10. Kuiu Island



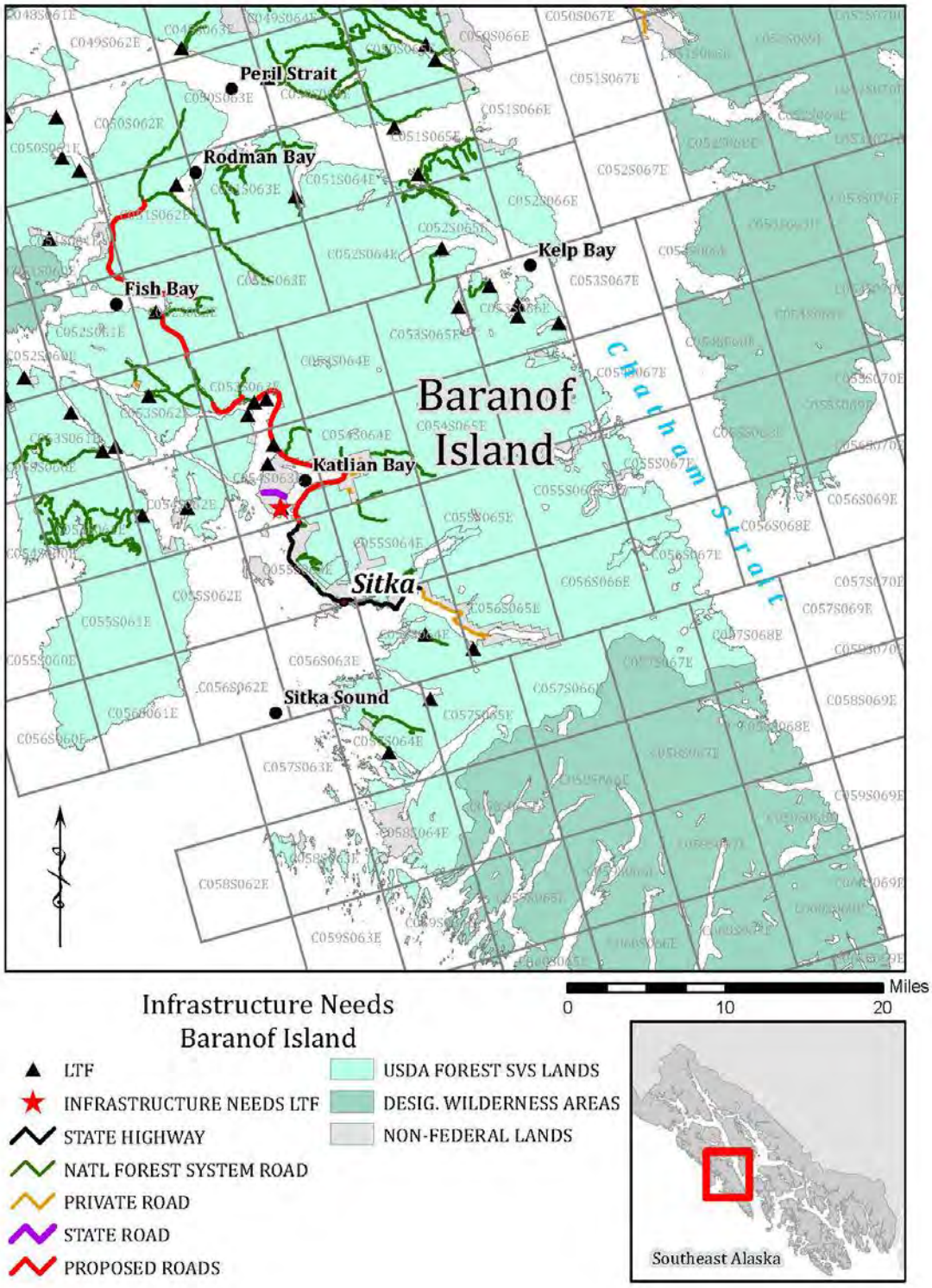
Map Developed by Alaska Mental Health Trust Land Office

Map 11. Chichagof Island



Map Developed by Alaska Mental Health Trust Land Office

Map 12. Baranof Island



Map Developed by Alaska Mental Health Trust Land Office

APPENDIX H: ALASKA TIMBER JOBS TASK FORCE (SHORT REPORT) – JULY 2012

REPORT TO GOVERNOR SEAN PARNELL
PREPARED BY ALASKA TIMBER JOBS TASK FORCE

ADMINISTRATIVE ORDER 258:

FINAL REPORT

ALASKA TIMBER JOBS TASK FORCE

The Alaska Timber Jobs Task Force is a combined federal, state, private industry, and community group appointed by Governor Parnell to review and recommend actions related to:

- management of state-owned forest land, establishment and expansion of legislatively-designated state forests, and state timber harvesting statutes and regulations, and
- Tongass National Forest management, southeast Alaska land ownership, southeast Alaska timber demand and supply, statewide current and potential wood products, and additional research needs.

Membership

Name	Title	Affiliation
Chris Maisch	State Forester (Task Force Chair)	Alaska Department of Natural Resources, Division of Forestry
Randy Bates	Director	Alaska Department of Fish and Game, Division of Habitat
Brad Cox	Logging and Milling Associates	Alaska Forest Products Industry
Bryce Dahlstrom	Viking Lumber Company	Alaska Forest Products Industry
Owen Graham	Alaska Forest Association	Alaska Forest Products Industry
Nicole Grewe	Economic Analyst	Alaska Department of Commerce, Community, and Economic Development, Division of Economic Development
Ruth Monahan[1]	Deputy Regional Forester	United States Department of Agriculture, Forest Service, Alaska Region
Elaine Price	Resident	Southeast Alaska communities
Randy Ruaro	Deputy Chief of Staff	Office of Governor Parnell

Contact information, meeting notes, reports, and additional information about the Alaska Timber Jobs Task Force may be found at: http://forestry.alaska.gov/aktimber_jobs_taskforce.htm

[1] Note: USFS liaison to Task Force, non-voting member. The USFS abstains from endorsing the findings and recommendations in this report. The USFS disagrees with several of the findings in Administrative Order No. 258. Many of those findings are at issue in ongoing litigation, including litigation the State of Alaska has initiated against the federal government. The USFS participation on the Task Force is limited to furthering the exchange of information and participation and should not be interpreted as agreement with findings or recommendations of the Task Force. The USFS is committed to continuing to manage the Tongass in accordance with applicable federal law and the Tongass forest plan, including the objectives of creating economic development opportunities and jobs for Alaska communities.

ALASKA TIMBER JOBS TASK FORCE JUNE 2012

EXECUTIVE SUMMARY

Between July 2011 and June 2012, the Alaska Timber Jobs Task Force (hereafter Task Force) reviewed and discussed numerous issues affecting Alaska's timber industry. This report summarizes the Task Force's recommendations to address all objectives detailed in Section 2 (Purpose) of Administrative Order 258 (Appendix 1), with a particular focus on job creation and economic development.

In sum, the Task Force identified the following priority statewide issues that present the greatest impediment to job creation and economic development for Alaska's timber industry:

1. Timber supply;
2. Workforce development; and
3. Public education and outreach.

ALASKA'S WORKING FORESTS

Alaska's federal and state forests have the potential to be a model of sustainability, including environmental, social, and economic objectives. The "Working Forest" concept embraces diverse and broad objectives related to utilizing natural resources, providing jobs, stimulating local economies, and supporting communities. These broad objectives have the potential to unify diverse stakeholders and interest groups while framing many of the State of Alaska's short- and long-term goals.

Working Forests:

1. Support industries that use Alaska's natural resources on a sustained-yield principle based on multiple-use management, consistent with public interest;
2. Manage timber resource production on a rotational basis to provide for a fully-integrated timber industry capable of producing a variety of products; and
3. Attract private-sector investment that establishes businesses, creates jobs, and provides community stability.

FINDINGS

The timber industry is vitally important to Alaska's statewide and regional economies. Timber industry challenges and opportunities vary by region, including Southcentral, Interior, and Southeast Alaska.

SOUTHCENTRAL AND INTERIOR

The timber industry in Interior Alaska is experiencing slow, but steady growth as wood biomass projects are developed to meet community needs for economic space heating and electrical generation. Projects at both small and large scales are made possible by state forest management policies that provide a sustainable, long-term supply of wood from state forests and other state lands.

In Southcentral, the creation of the Susitna State Forest would aid in developing access to lands, which in turn will increase timber sales for small mills and commercial firewood businesses. Other multiple use activities, such as personal use firewood, hunting, and other recreational uses will also benefit.

SOUTHEAST

The principal barrier to job creation in southeast Alaska's (Southeast) timber industry is insufficient timber volume from the Tongass National Forest (NF). Over the past decade (2001 – 2011), the Tongass NF has offered approximately 43% of the volume needed to meet its volume under contract (VUC) sale objectives identified in USFS annual timber demand reports (Appendix 9). Since the 2008 Tongass Land and Resource Management Plan (TLMP) amendment, the Tongass NF has offered only 33% of the volume the agency deems necessary to comply with Section 101 of the Tongass Timber Reform Act (TTRA), which requires the United States Department of Agriculture (USDA) to "…seek to provide a supply of timber from the Tongass National Forest which (1) meets the annual market demand for timber from the forest and (2) meets the annual market demand from such forest for each planning cycle."[2]

Uncertainties and exorbitant costs associated with the National Environmental Policy Act (NEPA) and invalidation of the Tongass Exemption to the 2001 Roadless Area Conservation Rule exacerbate the challenge of supplying sufficient timber volume from the Tongass NF to maintain an integrated timber industry capable of contributing meaningfully to the region's economy. The Task Force finds that:

1. The downward spiral of the Southeast timber industry has adversely affected Southeast communities, schools, and local economies;
2. Federal policies and management practices fail to provide sufficient timber supply for Southeast's timber industry;
3. The current USDA "Transition Framework" and associated USDA "Investment Strategy" for economic development being implemented in Southeast proposes to limit and then accelerate transition away from the traditional timber sale program on the Tongass NF in favor of young growth harvest and restoration activities, which is an uncertain alternative for sustaining Southeast communities; and
4. Environmental groups have exerted undue influence over USFS policy and direction related to national forest management in Alaska.

RECOMMENDATIONS

Task Force work and recommendations spanned eight substantive areas of interest including: 1) management of state-owned forests; 2) expansion of legislatively-designated state forests; 3) establishment of legislatively-designated state forests; 4) State of Alaska timber harvesting statutes and regulations; 5) Tongass National Forest ownership and management; 6) timber demand and supply; 7) wood products development; and 8) additional research needs.

Recommendations for each substantive area include short-, mid-, or long-term designations that refer to the estimated timeframe for action on the item: (S) = one to two years; (M) = three to four years; and (L) = five or more. Highest priority recommendations (Appendix 12) are denoted by an asterisk (*). Purpose statements from Administrative Order 258 are included to provide context and background for each set of recommendations.

[2] To the extent consistent with providing for the multiple use and sustained yield of all renewable forest resources

MANAGEMENT OF STATE-OWNED FOREST LAND

Administrative Order 258, Section 2, Task 1
Review, analyze, and prepare recommendations regarding management and care of the state forests that will lead to economical traditional timber harvests in the future.

1. (S) Establish a "Roads Office" in the Department of Natural Resources (DNR) to facilitate the planning and construction of resource development roads and access. As part of this recommendation, increase DNR's one time procurement level to $20 million. (See Appendix 2).
2. (S-M) Provide funding for basic and increased road maintenance and infrastructure development on the expanding statewide forest road system on state lands, especially on state forests. Current funding needed to implement this recommendation is estimated at $2.0 million.

EXPANSION OF LEGISLATIVELY-DESIGNATED STATE FORESTS

Administrative Order 258, Section 2, Task 2
Review, analyze, and prepare recommendations for future additions of state land to existing state forests.

1. (S) Tanana Valley State Forest: add remaining 1,124,613 acres of forest classified lands from the Tanana Basin Area Plan.
2. (M-L)* Southeast State Forest: add two million acres of National Forest System lands from the Tongass NF (also see recommendation 1 under Task 5).

ESTABLISHMENT OF LEGISLATIVELY-DESIGNATED STATE FORESTS

Administrative Order 258, Section 2, Task 3
Review, analyze, and prepare recommendations for the creation of new state forests where the primary emphasis on use will be for timber harvests and creation of economic development opportunity and jobs for Alaskans and their families

1. (S-M) Pursue creation of the following new State Forests:
   - Susitna State Forest – 763,200 acres[3]. (See Appendix 3).
   - Copper River Valley State Forest – 435,179 acres
   - Kenai State Forest – 154,726 acres (83,179 Kenai Peninsula and 71,547 Cook Inlet)
   - Icy Bay State Forest – 34,686 acres

STATE TIMBER HARVESTING STATUTES AND REGULATIONS

Administrative Order 258, Section 2, Task 4
Review, analyze, and prepare recommendations for amendments to state statutes or regulations governing timber harvesting that will lead to the creation of economic development and jobs for Alaskans and their families and communities

1. (S) 11 AAC 71.045. Negotiated Sales (e). This regulation currently limits the length of a contract negotiated under the conditions of AS 38.05.115 to one year, and prevents contract extensions. Amending 11 AAC 71.045 (e) to allow 2-year contracts for small negotiated sales would provide the

[3] Total acres from Susitna Area Plan (1985), Southeast Susitna Area Plan (2009), and Susitna Matanuska Area Plan (2011).

state a better tool for addressing the needs of small operators by providing them with longer windows of secure timber for their businesses (Appendix 4).

2. (S) AS 38.05.118. Negotiated Sales. Amending the following sections of this statute would allow the state increased flexibility using negotiated timber sales to meet local manufacturing needs (Appendix 4).
   - Amend statute AS 38.05.118(a) to require that the appraised value of the timber be re-determined every five years.
   - Amend statute AS 38.05.118(c) so only one of the three conditions has to exist within two years.
     - 11 AAC 71.055. Negotiated sales under AS 38.05.118. This regulation would require amendment to reflect changes to AS 38.05.118 recommended above.
3. (S) AS 38.05.945. Notice. Add the following language as Section (E) under AS 38.05.945(b)(3):
   - (E) Notice at least 30 days before the action by publication in newspapers of statewide circulation is not required for the sale of timber on less than 640 acres or the appraised value of the timber is less than $100,000 or the sale of timber is for a period less than five years.
4. (S) Archeological resources are important and need to be identified and protected; however, the cost of conducting required archeological surveys can often make an otherwise economical small timber sale uneconomical. Moreover, these surveys present significant costs for the DNR, Division of Forestry (DOF) when preparing larger state timber sales. Although the Task Force did not identify any statutory or regulatory amendments related to the State Historical Preservation Act (Appendix 5), the Task Force recommends the DOF and State Historical Preservation Office (SHPO) continue to work cooperatively to develop:
   - Programmatic work agreements;
   - Joint funding agreements/requests to fund survey work; and
   - Increased communications (formal and informal).

TONGASS NATIONAL FOREST LAND OWNERSHIP AND MANAGEMENT

Administrative Order 258, Section 2, Task 5
Review, analyze, and prepare recommendations related to state land selections in the Tongass National Forest and identification of lands already selected and conveyed or pending that have little or no economic use but may have other value and identification of federal lands for which an exchange could be offered to the federal government.

1. (M-L)* Pursue state ownership and/or management authority of two million acres of National Forest System lands in the Tongass NF to support an integrated timber industry in Southeast.
2. (S-L)* Work jointly with other states/entities seeking change in the management of federal lands. Possible changes include the concepts of "trust" or state management of federal lands, the transfer of federal lands into state ownership, adjustments to the Alaska Statehood Act by Congress and measures to force the federal agencies, primarily the USFS, to increase timber harvest.
3. (S) Support finalization of Sealaska's outstanding land entitlements, Alaska Mental Health Trust's administrative land exchange with the USFS, and settlement of land entitlements for the unrecognized Southeast Alaska Native Communities.

4. (M) Pursue an administrative land exchange with the federal government of approximately 250,000 acres of existing state-owned lands; dispersing the newly-acquired lands among Southeast communities and boroughs for community development and economic diversification.

TIMBER DEMAND AND SUPPLY

Administrative Order 258, Section 2, Task 6
Survey, study, and submit report to the state and federal government on current demand for timber in the Tongass National Forest and specific business and economic opportunities that could be supported by such demand, if timber were supplied.

1. (S) Support management, research, and legal efforts to assure access to adequate, consistent, and sustainable timber supply on federal and state forest lands. The development of new wood products and increased product diversity will lend strength to obtaining increased supply to support a diversified and sustainable forest products industry.
2. (S) Provide substantive state comments during the scheduled five-year TLMP review process advocating for community-based timber sales and timber supply appropriate to all types of business.
3. (S) Support additional research regarding local and regional socioeconomic impacts of declining timber supply, declining timber industry, and USFS forest management policy and practices in southeast Alaska.
4. (S) Support additional research regarding the timber supply needed to support a fully-integrated timber industry, including all direct and indirect forestry support enterprises.
5. (S-M) Support efforts to frame State and National Forests in Alaska as working forests for Alaska's communities and economies. This effort is largely one of providing resources for developing a public education and outreach strategy regarding Alaska and its communities, peoples, and forests. Where necessary, address misinformation about forest management in Alaska.

Administrative Order 258, Section 2, Task 7
Review, identify, and report quarterly to state and federal governments on possible timber sales in the Tongass National Forest that would meet demand with economical timber sales, including the identification of possible ten-year timber sales.

1. (S)* Utilize all political and policy avenues to ensure – in addition to all current timber sale projects on the Tongass NF – the USFS begins the planning process necessary to advertise four ten-year timber sales, each with an average timber volume of 15 – 20 million board feet (MMBF) per year.
2. (S) Under existing memorandums and agreements with the USFS, direct state agencies to actively participate in the scheduled five-year review of TLMP with a goal that includes promoting revisions to TLMP that would provide an economic timber volume capable of sustaining a fully integrated timber industry. Revisions to the Wildlife Conservation Strategy, Land Use Designations, Scenic Integrity Objectives, and Visual Priority Routes of TLMP are critical for achieving this objective.
3. (S)* Pursue all opportunities for exempting Alaska national forests from the 2001 Roadless Area Conservation Rule.
4. (S) Maintain and expand the state-federal relationship and increase state participation in the internal design and review process for timber sales and Integrated Resource Management Projects (IRMP) on the Tongass NF.

5. (S) Review, revise, renew, and where appropriate, consolidate state-federal memorandums of understanding governing cooperative efforts.
    - State participation has the greatest benefit when it is consistently provided from the beginning (Gate 1) and throughout the timber sale planning process; especially participation on the Joint Review Team.
    - Formalize state cooperation and collaboration regarding implementation of TLMP through an updated Memorandum of Understanding. Clarify communication, roles, points of engagement in project planning processes, and frequency of coordination meetings.
6. (S) Continue the Gate 3 Committee, which includes state and federal staff and industry representatives. Include the committee in the annual monitoring and evaluation process of TLMP.
7. (S) Consider seeking Cooperating Agency status available under NEPA, when appropriate, to ensure greater participation by the state in federal decision-making.
8. (S) Support the State Tongass Team by clarifying its organization and responsibilities for engaging with the USFS.
9. (S) Develop cooperative agreements with the USFS to improve project and permit coordination and approval.

WOOD PRODUCTS DEVELOPMENT

Administrative Order 258, Section 2, Task 8
Review, identify, and report to the state and federal governments on current wood products and potential new products and uses, such as biofuel and cellulosic ethanol, that could be made from timber supplied by the Tongass National Forest.

1. (S) Increase focus and support for products that utilize all primary and secondary timber resource materials.
2. (S) Promote new wood products and increased wood product diversity.
3. (S-M) Support workforce development, through established public sector programs, to improve workforce skills, knowledge, and abilities.
4. (S-M) Support additional research regarding grading impacts, market feasibility of new wood products and value-added wood products, full resource utilization, and maximizing product manufacturing efficiencies.
5. (S) Provide additional marketing support for high-value wood products manufacturers. Greater access to local markets and greater marketing tools for small operators will improve this segment of the industry.
6. (S) Provide technical assistance for entrepreneurs and small businesses considering new wood products, expanding business operations, or considering other innovative business or product development ideas.

ADDITIONAL RESEARCH NEEDS

AO258, Section 2, Task 9:
Review and submit recommended areas of research related to use of the Tongass National Forest and impacts on wildlife.

1. (S-M) Provide sufficient funding to the Alaska Department of Fish and Game to conduct research necessary for (Appendix 11):
    - Estimating wolf populations in Game Management Units (GMU) 2 and 3;

- Completing development and evaluation of DNA-based methods for estimating deer population abundance in southeast Alaska; and
- Estimating deer numbers in GMU 3 using DNA-based methods, and assessing causes and rates of mortality.

APPENDICES

Appendix 1: Administrative Order 258
Appendix 2: Division of Forestry Engineering Needs for Large Construction Projects (Task 1)
Appendix 3: Susitna State Forest Public Briefing Paper and Map (Task 2)
Appendix 4: Review of Alaska Timber Sale Statutes (Task 4)
Appendix 5: SHPO Evaluation (Task 4)
Appendix 6: Task 5 Final Report
Appendix 7: State Lands and Future Exchange (Task 5)
Appendix 8: Task 6 Final Report
Appendix 9: Tongass Timber Sale Program 2001-2011 (Task 7)
Appendix 10: Task 8 Final Report
Appendix 11: ADF&G Research (Task 9)
Appendix 12: High Priority Recommendation Matrix
Appendix 13: Timber Jobs Task Force Preliminary Report to the Governor (9-15-11)

ACKNOWLEDGEMENTS

The Task Force appreciates the hard work demonstrated by countless DNR, DCCED, ADFG, DOTPF, and USFS staff. Information provided by the aforementioned agencies and respective staffs was instrumental in completing Task Force work and compiling the final report. The Task Force equally appreciates individuals of the public that attended meetings and provided public comment that contributed to our understanding of these important, complex issues. Finally, the Task Force thanks the community of Coffman Cove. Your hospitality laid the foundation for one of the most productive and memorable Task Force meetings.

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The Working Forest Group (TWFG). *Analysis of Old Growth Inventory and Land Base Available for Operations within the Tongass National Forest.* June 2014. Print.

U.S. Department of Agriculture. *Tongass Integrated Plan.* USDA Forest Service. Web. 26 December 2014. http://www.fs.usda.gov/detail/tongass/landmanagement/?cid=stelprd3812864

CITY AND BOROUGH OF WRANGELL

INCORPORATED MAY 30, 2008

P.O. BOX 531 (907)-874-2381
Wrangell, AK 99929 FAX (907)-874-3952
www.wrangell.com

February 22, 2015

Forest Supervisor
Tongass national Forest
Attn: Forest Plan Amendment
648 Mission Street
Ketchikan, AK 99901

Re: Comments on Proposed Tongass Nation Forest Land and Resource Management Plan
And the draft EIS

Thank you for allowing us this opportunity to comment on the Proposed Tongass National Forest Land and Resource Management Plan and the draft EIS.

Our understanding is that the primary changes in this plan is focusing on the transition from harvesting old growth to young growth. But as a community who has experienced the downside of the lack of a supply of old growth timber, we are concerned in the ability of the USFS to provide an economically viable supply of young growth timber, and to do it within the 15 year time frame as charged by the Secretary of Agriculture. We are concerned that the inventory data is generalized, and therefore we support and encourage development of an accurate inventory of young growth availability.

This inventory is critical for a complete and accurate economic analysis of the transition on communities and industry. Loss of harvesting volume is not a result in decline in demand, it is a result from the loss of economic sales available to industry and the slow process the USFS undertakes to develop sales due to an ongoing fear of lawsuits. No business can operate economically in such an environment and thus the loss in industry opportunity.

- The plan fails to consider social and economic metrics to measure outcomes of the transition from old growth to young growth. Metrics showing the impacts to industry and also to communities.

- Appendix C Watershed Analysis: There has been so much discussion of late regarding "watershed" analysis and impacts within the T77 watersheds. Based on our own personal experience with the Wrangell Island Sale, an actual stream "watershed" for a harvest unit or harvest area, may be smaller than the T77 defined watershed. Yet the USFS is trying to utilize the T77 watershed analysis. The Plan needs to clarify its definition and use of watershed analysis vs. the T77 watersheds.

- We support the relaxation of Standards and Guides for the harvest of Young Growth during the transition in land use designations that may normally minimize or prohibit some commercial harvesting if it will provide economic sales of young growth timber.

- Appendix F Visual Priority Routes and Scenic Integrity. According to our Wrangell District, for some reason it appears that all of Wrangell's Forest Roads are designated a Visual Priority Route. While we agree that the main roads do have a visual preference, not all of the roads need to be classified a visual priority route to limit timber or other use. (Originally, some of these designations were going to be dealt with in the upcoming Wrangell Island Sale, but now we understand that will not happen and we have to address it here. Only the road management plan – what stays open, what will be closed and level of use will now be addressed in the Wrangell Island Sale.) For example, the back side of the Nemo-Skip Loop Road (6267) (From Turn Island where the road turns northeast back to intersection of #6265 to Earl West) is heavily timbered and more out of site out of mind and a good area in which to continue to permit timber harvest. Yes it is on a loop so makes for a fun day trip, but there is nothing wrong with timber harvesting. Questions can be answered with educational materials about timber harvesting practices and economic values to communities.
  Every road on Wrangell Island will meet one of the primary criteria for a visual priority route – for example the water routes of small and midsize boats. We are on an island. Timber roads climb mountains that provide views, over looks are created for turn outs for logging trucks and once trees are harvested, you can see the water. It does not mean that each road should be a visual priority route. All roads should be analyzed as a whole, and key stretches of roads identified. Off shoots of some of the priority roads that receive minimal traffic could be reclassified as non visual priority.

- Tourism is the big growth industry since supply of timber to harvest and political affects have reduced the opportunity for the timber industry. The plan also fails in considering the social and economic metrics to measure outcomes of tourism growth for communities and businesses and the impacts to recreational sites

We understand that the USFS has selected as its preferred alternative, Alternative 5 that was proposed by the Tongass Advisory Committee. While the Borough is not agreeing or disagreeing with that alternative specifically, we do understand that their proposed amendment included additional recommendations that were not necessarily "plan" amendments. Yet their recommendation was to be presented as a package. If Alternative 5 is implemented, we believe the other components of their recommendation, including the monitoring, bringing stakeholder participation in earlier in planning processes, USFS internal culture change, inventory assessments and social economic impact analysis are critical components of any plan implementation strategy.

Sincerely,

Jeff Jabusch
Borough Manager

CC: Mayor David Jack
Borough Assembly
Carol Rushmore, Economic Director/Planner