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U.S. DEPARTMENT OF AGRICULTURE

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Forest Health Conditions in Alaska - 2020

A Forest Health Protection Report

U.S. Department of Agriculture, Forest Service, State & Private Forestry, Alaska Region

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Cover photo: Spruce needle rust recorded during ground surveys along the Denali Highway, USDA Forest Service photo by Steve Swenson.

You can request our aerial survey team to examine specific forest health concerns in your area.
Simply include the information below in an email to:

Karen Hutten, Forest Service S&PF/FHP
email: karen.hutten@usda.gov

Name:____

Organization:____

Contact Information:____

General description of forest health concern (hosts species affected, damage type, disease or insects observed).
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The general location of damage. If possible, attach a map or marked USGS Quadrangle map or provide GPS coordinates. Please be as specific as possible, such as reference to island, river drainage, lake system, nearest locale/town/village.
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Do you need additional forest pest information (e.g., GIS data, extra copies of the 2020 Forest Health Conditions in Alaska Report, etc.)? Please be as specific as possible. If hardcopies are desired, provide a mailing address.
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WE NEED YOUR FEEDBACK

Would you like to remain on our mailing list for the annual Forest Health Conditions in Alaska Report?
Simply fill out this form and return it to:
Garret Dubois, Forest Service
S&PF/FHP, 3700 Airport Way, Fairbanks, AK 99709
Phone (907) 374-3758; fax (907) 451-2690; email: garret.d.dubois@usda.gov

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Do corrections need to be made to your physical or electronic address? Has the contact person for your organization changed? Please update any details here.
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How can we make this report more useful to you and/or your organization?
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How do you and/or your organization use the information in this report and/or maps on our website (www.fs.usda.gov/goto/r10/fhp)?
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Forest Health Conditions in Alaska - 2020

FHP Report R10-PR-46

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Introduction

We are excited to present the *Forest Health Conditions in Alaska—2020* report. This report summarizes monitoring data collected annually by our Forest Health Protection team, the Alaska Division of Forestry team, and some other key partners.

It is provided to you, as one of our core missions, to provide technical assistance and information to stakeholders on the forest conditions of Alaska. The report also helps to fulfill a congressional mandate (The Cooperative Forestry Assistance Act of 1978, as amended) that requires survey, monitoring, and annual reporting of the health of the forests. This report also provides information used in the annual *Forest Insect and Disease Conditions in the United States* report.

We hope this report will help **YOU**, whether you are a resource professional, land manager, other decision-maker, or someone who is interested in forest health issues affecting Alaska. This report integrates information from many sources, summarized and synthesized by our forest health team. Please feel free to contact us if you have any questions or comments.

We also want to let you know about some recent personnel changes in our Alaska forest health team:

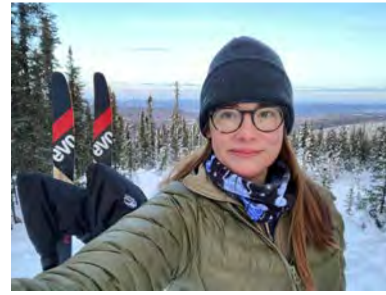
New Arrivals: Please join us in welcoming **Dr. Sydney Brannoch**, who joined Forest Health Protection (FHP) as the new Entomologist based out of Fairbanks in August 2020. Sydney, who replaces Dr. Stephen Burr, recently finished up a postdoc at the University of Washington, Seattle, where she led a research project on snow fly (*Chionea* spp.) taxonomy and cold tolerance physiology. Sydney earned her Ph.D. in Biology in 2019 from Case Western Reserve University with a dual appointment at the Cleveland Museum of Natural History in Cleveland, Ohio, where she focused on insect morphology, taxonomy, and physiology. **Isaac Dell** is the new Biological Scientist based out of Juneau. He started working for Forest Health Protection in 2015 in Colorado. In 2018, Isaac completed a master's degree in Forest Science at Colorado State University, where he studied the effects of temperature on spruce beetle flight phenology and fecundity. **Jessie Moan** is joining our Forest Health Protection team as the new Entomologist in the Anchorage office. Jessie has been in Alaska and part of the wider forest health community since late 2013. She joined FHP in July 2020 from the University of Alaska Fairbanks, Cooperative Extension Service where she worked for 6.5 years monitoring forest health, helping homeowners and landowners with tree and forest health questions, and developing tree and forest health outreach and education materials. You can read an early introduction of Jessie in the 2014 Forest Health Conditions report. Jessie comes in behind Dr. John Lundquist who retired in the spring of 2018.

Recent Departures: Congratulations to **Debbie Hollen** on her new position as the R6 Deputy Regional Forester. Debbie served as Regional Director, State & Private Forestry for R6 & R10 since 2016 and will be greatly missed. We bid farewell to our Seasonal Technicians! **Dana Brennan** worked as a Seasonal Technician based out of Fairbanks for three seasons. She recently started a new position with the Alaska Department of Environmental Conservation as an Environmental Program Specialist II. **Isaac Davis** worked as a Seasonal Technician for five seasons, the first of which was in Fairbanks with the remainder based out of Juneau. Isaac will be working with Region 6 (Washington and Oregon) on their Aerial Detection scan and sketch surveys. **Alex Wenninger** worked as a Seasonal Technician for three seasons based out of Anchorage. Alex has recently accepted a position as the Integrated Pest Management Program Assistant with the University of Alaska, Fairbanks' Cooperative Extension Service. Thank you Dana, Isaac, and Alex; we wish you all the very best!

By Michael Shephard, Deputy Director for State & Private Forestry, USDA Forest Service, Alaska Region.

Did you know that you can request our aerial survey team to examine specific forest health concerns in your area? To do this, please contact Karen Hutten (karen.hutten@usda.gov) or other members of our forest health team.

Additionally, this report is available online at (https://www.fs.usda.gov/goto/ForestHealthReports) or in print by contacting Biological Science Technician, Garret Dubois (garret.d.dubois@usda.gov).



Dr. Sydney Brannoch

Isaac Dell

Jessie Moan

Dana Brennan

Isaac Davis

Alex Wenninger

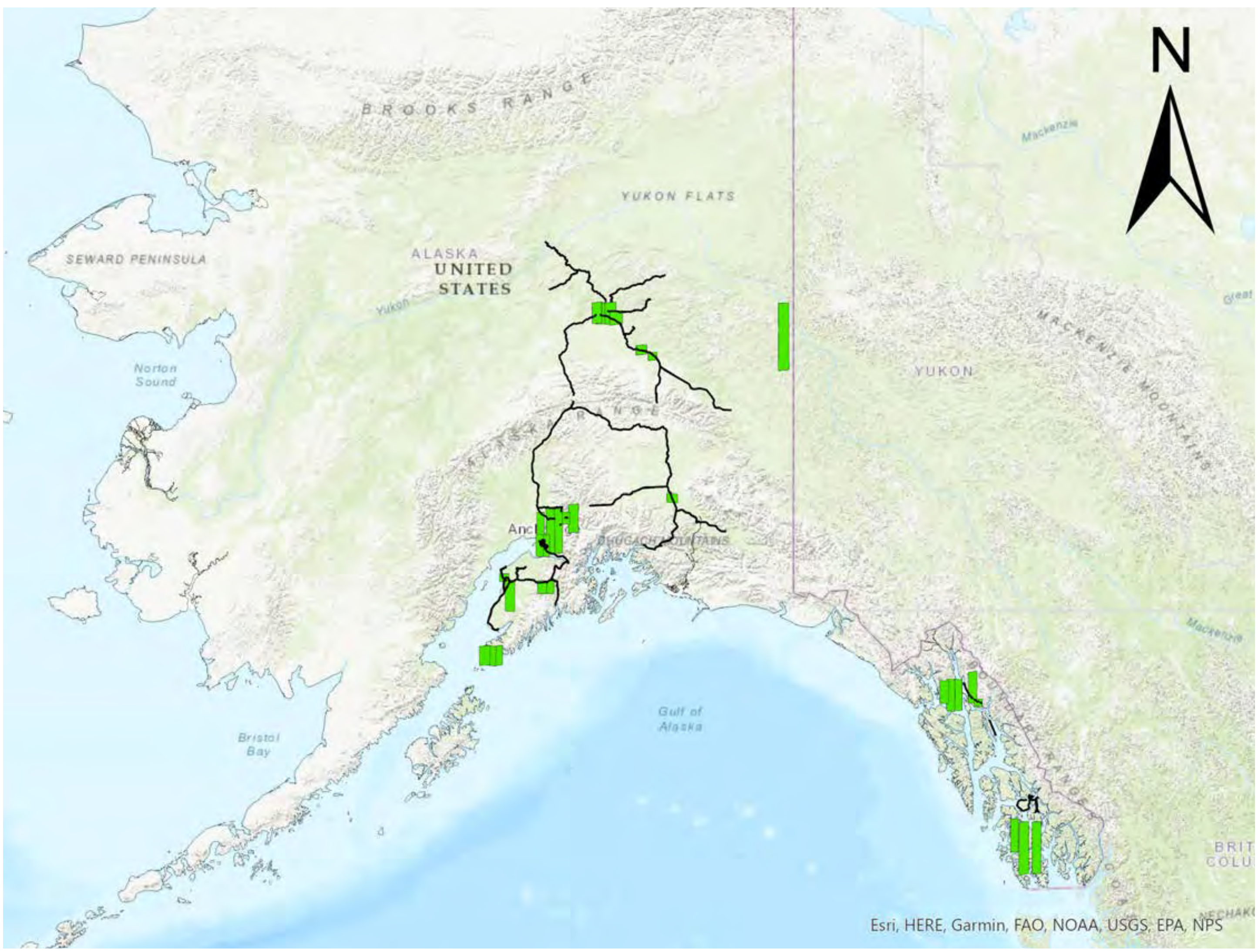
2020 Alaska Region Forest Health Highlights

The 126 million acres of forestland in Alaska represent 17 percent of the Nation's forests. In 2020, aerial surveys to detect active forest damage from insects, diseases, declines, and abiotic agents were grounded for the first time in decades due to the COVID-19 pandemic. In a typical year, our team aerially surveys around 20 million acres, or 15%, of the forested area of Alaska. An extensive ground survey approach in forests along roads and trails, in addition to remote-sensing techniques utilizing high-resolution satellite imagery (Map 3, page 7), (Map 4, page 8) enabled our team to gather the best forest health information possible given the current constraints (Table 1, page 9) (Table 2, page 10). We also created an Alaska Forest Health project in iNaturalist to solicit observations from citizen scientists (Table 3). The remote-sensing methods and crowd-sourcing techniques developed to meet current challenges will undoubtedly enhance our forest health surveys in the coming years.

Novel Survey Approaches

Combining Ground Surveys & Remote Sensing
We conducted ground surveys along roads and trails, mapping major damage at regular intervals. These surveys covered approximately 2.4 million acres. Our goal was to capture major damage observations, approximating what would be mapped during our annual aerial survey, thereby providing damage locations to hone our remote-sensing tools and techniques. As in recent years, we also recorded damage that is indecipherable from the air using the Survey123 app. This information is displayed in the ground survey dashboard and can be viewed at: https://arcg.is/1SH58a.

Based on locations with known forest damage, we evaluated damage signatures in high-resolution satellite imagery. This approach enabled us to map similar damage across broader and less accessible swaths of the landscape. High-resolution (< 1m) Worldview 2 and Worldview 3 satellite imagery captured June to September 2020 was requested for specific areas of interest through both Digital Globe and the



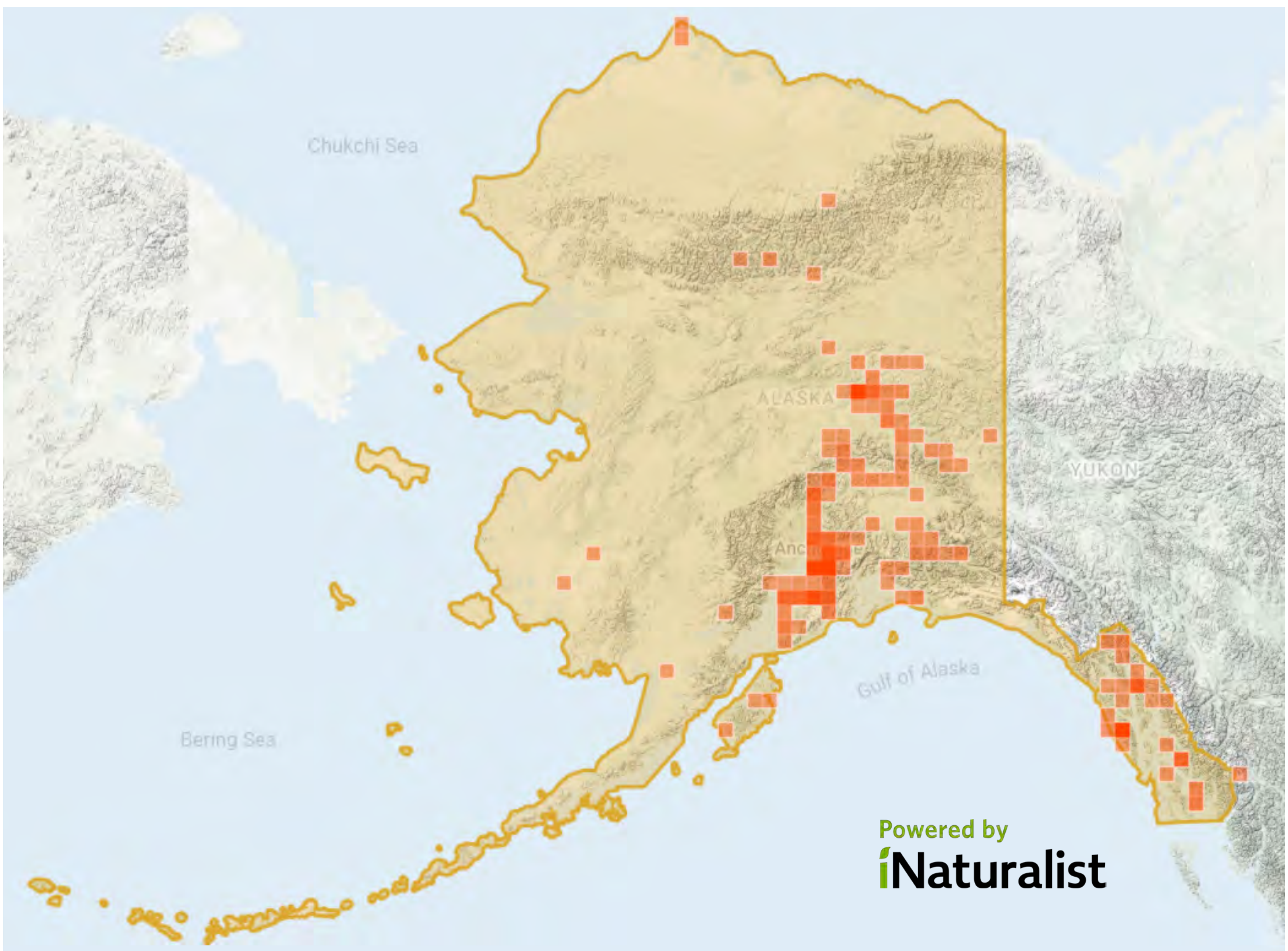
Map 1. Ground surveys along roads were performed (black routes) and high-resolution imagery (green polygons) was systematically scanned, resulting in nearly 345,000 acres of damage mapped across 7.3 million acres surveyed in 2020.

USGS using their Commercial Remote Sensing Space Policy (CRSSP) Imagery Derived Requirements (CIDR) imagery request tool. Available imagery was mosaicked (overlaid and positioned) in ArcPro software to create basemaps, which were then imported into our standard aerial survey mapping software on mobile tablets.

Using a newly developed method called scan and sketch survey, surveyors systematically scanned 4.8 million forested acres of imagery for forest damage. Using similar methods as aerial survey, surveyors circled damage areas, attributing them with a damage agent, plant host, and damage severity. Imagery quality varied and damage was often more difficult to see in imagery compared to what can be seen from the plane at 1000-1500ft above the ground. Some agents that cause relatively homogenous and distinct color change to the tree canopy (e.g., spruce beetle, aspen leafminer, and hemlock sawfly) were easier to pick up in the high-resolution imagery compared to more subtle or scattered damage that can be mapped from a survey plane. Fortunately, those agents that were difficult to identify could still be recorded during ground surveys. Using both road and remote-sensing surveys (Map 1), we mapped nearly 345,000 acres of damage across 7.3 million acres surveyed (4.8 million acres surveyed with remote-sensing and 2.5 million acres ground surveyed). A detailed description of the remote-sensing approach to damage detection based on high-resolution satellite imagery can be found in Appendix 1 on page 66.

iNaturalist

This year, we established a citizen science project in iNaturalist, a social media platform that allows users to upload biotic observations, called "Alaska Forest Health Observations." This allows us to tap into data that citizen scientists are already uploading from their backyards, roadsides, trails, remote islands, and even National Parks and Forests. We will continue to use this dataset to rapidly assess where forest damage agents have been observed and outbreaks may be building and to keep a finger on the pulse of forest health concerns of the public. Remarkably, between April and December, 312 observers uploaded 2,471 forest health observations of 217 different species in Alaska to our Alaska Forest Health Project in iNaturalist (Map 2; Table 3, page 11)! This year, iNaturalist observations of the previously undetected western tent caterpillar were crucial to assessing its current distribution.



Map 2. Map of citizen science observations recorded on iNaturalist in Alaska between May and December 2020 (Available from https://www.inaturalist.org. Accessed 12/10/20).

Disease Highlights

Aspen running canker is an aggressive canker disease that spreads rapidly along tree boles. First noted in 2015, this disease occurs throughout the boreal forest of Interior and Southcentral Alaska. We have isolated the elusive causal fungus, which often does not produce diagnostic fruiting structures and conducted inoculation trials to demonstrate the pathogenicity of the causal agent. We have named the newly described fungal pathogen *Neodothiora populina* Crous, G.C. Adams & Winton (Figure 1). We completed a study with Dr. Roger Ruess to understand the main factors influencing disease distribution and tree responses to infection; a shading experiment and gene expression studies are still underway.

Sirococcus shoot blight (*Sirococcus tsugae*) activity was more pronounced on western and mountain hemlock in the vicinity of Juneau in 2020 than it has been for at least a decade. The causal fungus benefits from the cool, wet conditions that were common this year. In general, these conditions exacerbate foliage and shoot diseases, and elevated damage to multiple tree and shrub species was observed in coastal Alaska. Sirococcus shoot blight was likely widespread in unsurveyed areas throughout the Panhandle. Some locations are subject to chronic infection that can permanently stunt tree form.

Noninfectious Highlights

The cause of western redcedar topkill on Prince of Wales Island is under investigation. This problem usually affects trees 5 to 12 inches in diameter and is most concentrated along roads (Figure 2). Drought is thought to be the most important abiotic cause, which may predispose trees to biotic stressors. Severe drought occurred on Prince of Wales Island in 2018 and 2019, followed by excessive rainfall in 2020. There is now a multi-regional and -agency effort to understand the abiotic and biotic causes of the notable increase of western redcedar mortality through the Pacific Northwest. Curiously, topkill and mortality was first noted in 2017, prior to severe drought onset. A retrospective analysis of weather in 2015 and 2016 may reveal abiotic stressors that triggered topkill observed in 2017.

Yellow-cedar decline, caused by root-freezing injury in the absence of insulating snowpack, is the most significant threat to yellow-cedar populations in Alaska. More than 600,000 cumulative acres of yellow-cedar decline have been aerially mapped. In 2020, surveys focused entirely on available high-resolution satellite imagery of Prince of Wales Island and the southern tip of Etolin Island. More than 10,000 acres of active decline (discolored trees) were detected. The use of high-resolution satellite imagery to map new or cumulative decline may help us to develop the most fine-scale and comprehensive decline layer. We maintain the yellow-cedar young-growth database of managed stands on the Tongass National Forest known to contain yellow-cedar (now 338 stands). Decline has now been detected in

Figure 1. Photo-plate of *Neodothiora populina* Crous, G.C. Adams & Winton, the newly confirmed cause of aspen running canker (from Crous et al. 2020. Persoonia 45: 251-409).

Figure 2. Topkill of western redcedar observed on Prince of Wales Island. USDA Forest Service photo by Molly Simonson.

18 percent of these stands that fall within the highest-risk age bracket (27-45 years old).

Invasive Plants Highlights

We are pleased to announce a new edition of our popular Invasive Plants of Alaska guide, of which there are more than 11,000 copies in circulation (Figure 3). The guide has been improved with fresh photos and content. Most importantly, four serious invasive plants have been added to the guide: giant hogweed, creeping buttercup, Elodea, and European mountain-ash. The online version can be found at https://www.fs.usda.gov/goto/InvasivePlantPubs and hard copies will be available in time.

This year, the Southeast Alaska Watershed Coalition (SAWC) and its partners successfully achieved control of a large Bohemian knotweed (*Fallopia* x*bohemica*) infestation near the Twin Lakes City Park in Juneau! City and Borough of Juneau park lands staff coordinated with Alaska Department of Transportation crews to combine effective mechanical and chemical treatments. Following eradication treatments, community groups revegetated the area with more than 150 thimbleberry and salmonberry plants. This work was funded by the Avista Foundation. SAWC works closely with U.S. Department of Agriculture, Forest Service on invasive species management and outreach.

In 2020, a large cooperative project was initiated to treat a 15-acre reed canarygrass (*Phalaris arundinacea*) infestation along a powerline corridor near Cooper Landing on the Kenai Peninsula. The powerline had been used as a fuel break during the 2019 Swan Lake Fire, spreading already established canarygrass that had been identified for treatment. Before the fire, the Forest Service was working with Homer Electric Association on a cooperative treatment plan. The infestation's close proximity to a prized salmon fishing site on the Russian River made treatment a high priority. A partnership between the Forest Service, Homer Electric Association, the Homer Soil and Watershed Conservation District and the Kenai Watershed Forum made this project possible. Funding sources included Forest Service Burned Area Emergency Response, Homer Electric Association, the Forest Service Forest Health Protection, and other grants.

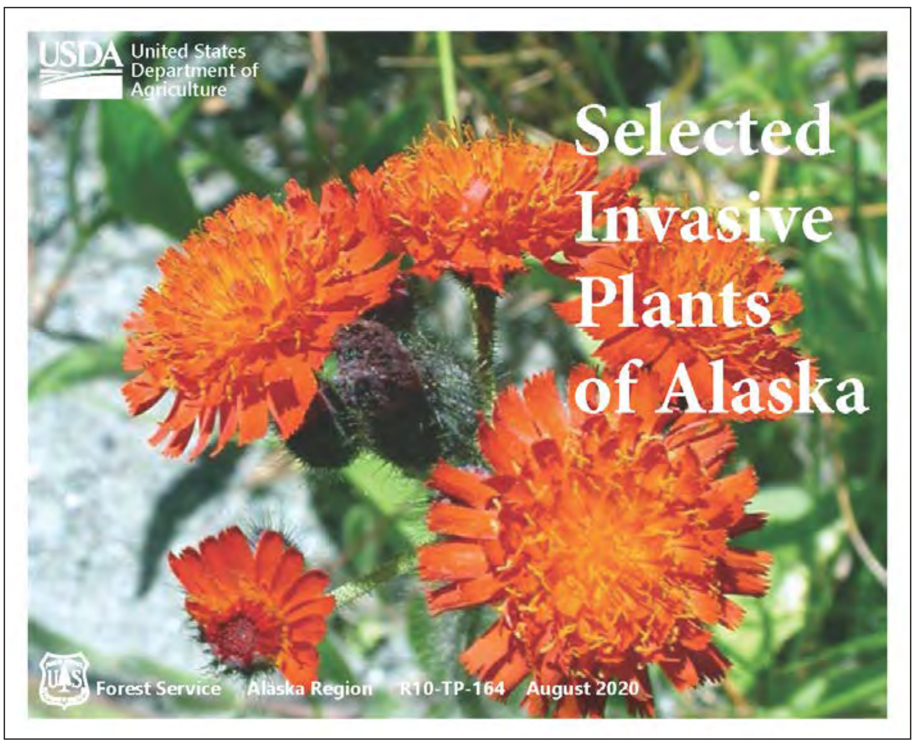


Figure 3. Cover image of the uodated Selected Invasive Plants of Alaska guide, which was released Fall 2020.

Figure 4. Spruce beetle damage and mortality observed in Trapper Creek during the Fall of 2020. USDA Forest Service photo by Sydney Brannoch.

Insect Highlights

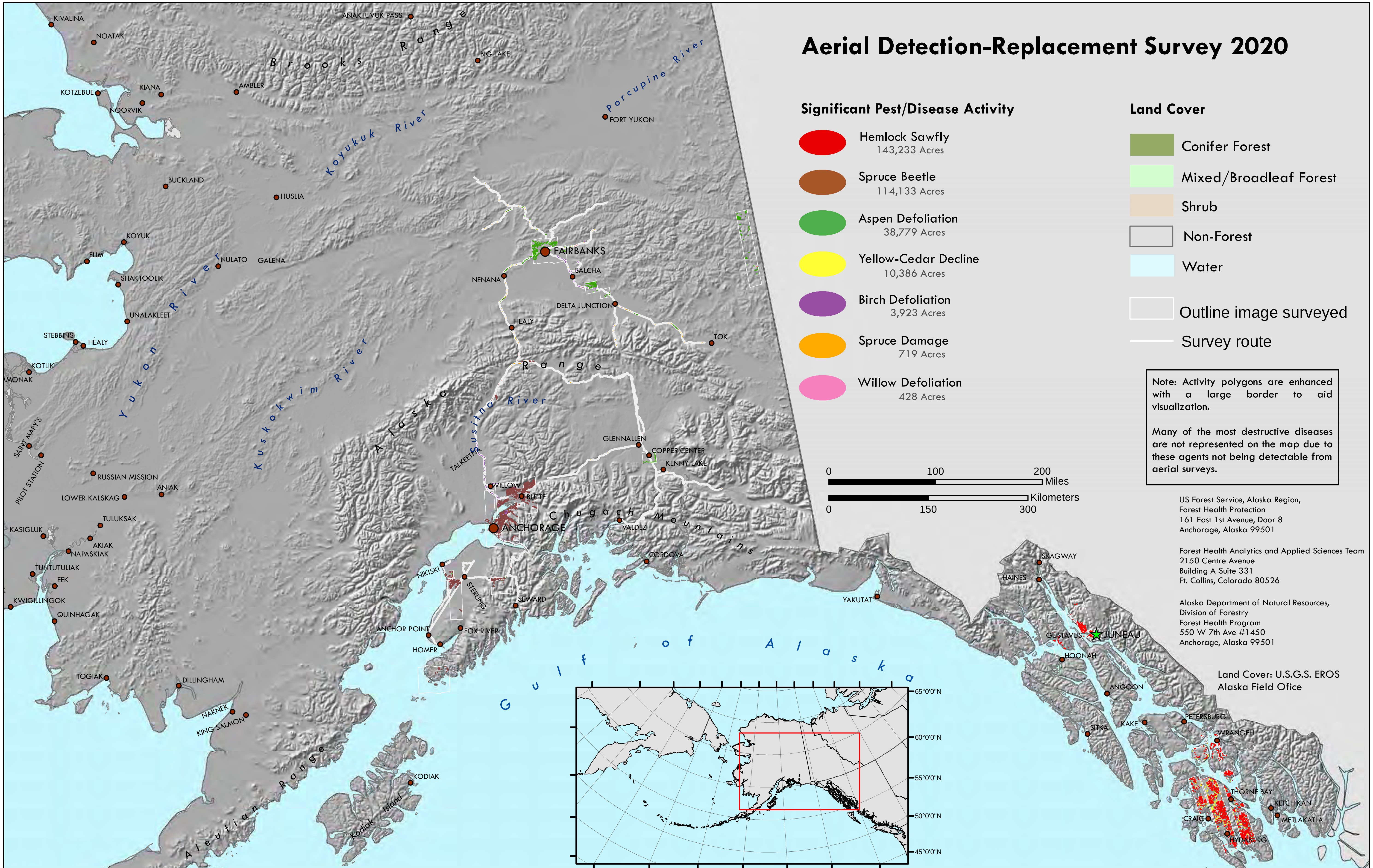
The ongoing spruce beetle outbreak has impacted over 1.2 million acres in Southcentral Alaska since it was first detected in 2016 (Figure 4). This year, we used remote sensing tools and ground surveys to identify more than 145,000 acres of spruce beetle activity in Southcentral Alaska. Damage expanded along the fringes of the most severe outbreak areas of the Susitna River valley and associated drainages and near Cooper Landing on the Kenai Peninsula. Spruce beetle activity in the Municipality of Anchorage has historically been difficult to assess due to airspace traffic issues, but the use of satellite imagery in 2020 allowed for a more complete assessment of spruce mortality in the Anchorage area.

Hemlock sawfly activity has decreased throughout Southeast Alaska, with over 143,000 acres of damage recorded using scan and sketch survey. Ground observations have also shown a decrease in larval activity. Mortality associated with hemlock sawfly defoliation was recorded on more than 80,000 acres; however, mortality is likely to be far greater across the full outbreak area. For more detailed information on hemlock sawfly activity, see the essay on page 14.

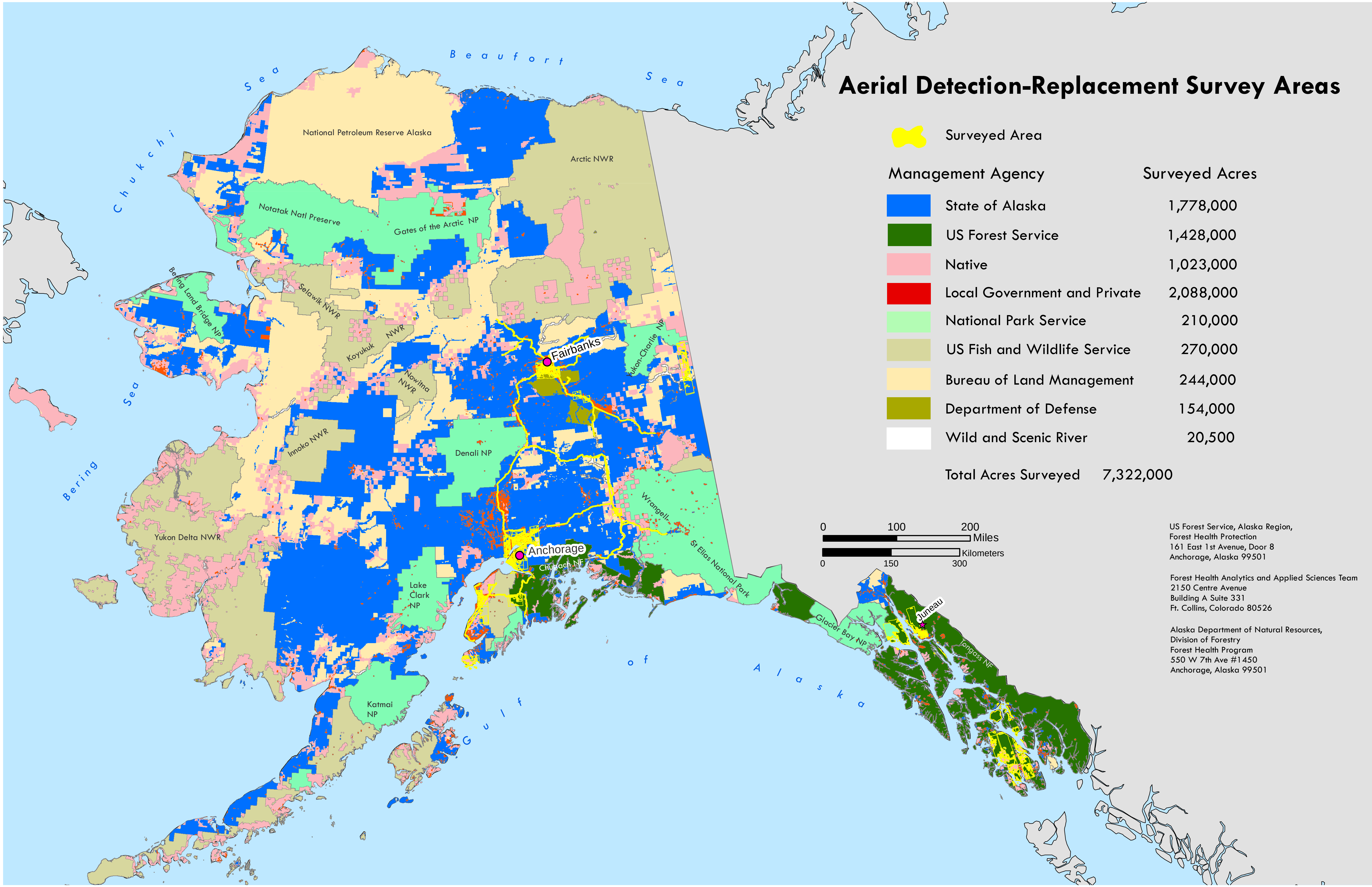
Rusty tussock moth was reported at numerous locations across the state in 2020 including Southcentral Alaska, the Bethel area, near Fairbanks, and on the Seward Peninsula, where an outbreak occurred in 2019. Notably high populations occurred in Southcentral Alaska, including 35 acres with low-level defoliation documented near Hatcher Pass. Rusty tussock moth caterpillars (Figure 5) were prevalent along the road system within the Matanuska-Susitna valley, though defoliation was generally minimal. Substantial defoliation, however, was reported in some areas at or above treeline in this region. Reports were received of caterpillars feeding on several berry species, tree and shrub species, and numerous garden plants.

In June 2020, reports were received about aggregations of caterpillars in silken tents infesting red alder in the Mountain Point area of Ketchikan. The species was initially identified based on photographs as western tent caterpillar. Specimens were collected by our colleagues on the Ketchikan Ranger District and reared to adults to confirm this identification. Additional observations of western tent caterpillars in Ketchikan and Hyder were confirmed from iNaturalist reports. Western tent caterpillars are not known to occur in Alaska but are found in nearby British Columbia. It is likely their establishment in Ketchikan is a result of range expansion; however, further surveys are needed to confirm.

Figure 5. A rusty tussock moth caterpillar, with its characteristic tussocks of whitish-yellow hair, on a leaf. USDA Forest Service photo by Steve Swenson.



Map 3. 2020 Aerial Detection-Replacement Survey. For more information on changes to the survey methods in 2020, please see Appendix 1, page 66.



Map 4. 2020 Aerial Detection-Replacement Survey areas. For more information on changes to the survey methods in 2020, please see Appendix 1, page 66

Table 1. Damage acreage mapped in 2020 across land ownerships during Aerial Detection-Replacement Surveys (7.3 milliion acres surveyed). Forest health damage is typically assessed by aerial detection survey flights, which could not be flown in 2020 due to COVID-19 restrictions. Therefore, comparing acreage totals from 2020 to other survey years is not recommended due to the difference in survey method. For a detailed description of survey methods, see Appendix 1 on page 73.

Category	Agent	Total Acres	National Forest	Native	Other Federal	State & Private
Pathogens	Alder dieback	971	0	0	965	6
Pathogens	Spruce broom rust	47	0	3	1	42
Pathogens	Spruce needle cast	36	0	0	0	36
Pathogens	Spruce needle rust	573	0	156	186	231
Pathogens	Western gall rust on pine	3	0	0	0	3
Pathogens	Willow leaf rust	18	0	0	0	18
Noninfectious Disorders	Drought	151	22	0	40	89
Noninfectious Disorders	Flooding/high-water damage	35	11	12	3	9
Noninfectious Disorders	Hemlock flagging	2	0	0	0	2
Noninfectious Disorders	Porcupine damage	121	55	0	0	66
Noninfectious Disorders	Western redcedar topkill	4	1	2	0	1
Noninfectious Disorders	Unknown abiotic	2	0	0	2	
Noninfectious Disorders	Windthrow/blowdown	14	9	0	0	5
Noninfectious Disorders	Yellow-cedar decline	10,386	7,734	2,286	0	366
Insects	Aspen leafminer	38,707	0	4,513	1,401	32,793
Insects	Birch aphid	224	0	0	142	82
Insects	Birch leafminer	2,846	0	0	267	2,579
Insects	Hemlock sawfly (defoliation)[1]	124,416	88,513	14,059	722	21,122
Insects	Hemlock sawfly (mortality)[1]	80,067	63,891	10,226	0	5,949
Insects	Hemlock sawfly total[2]	143,233	103,834	16,124	722	22,553
Insects	Rusty tussock moth	35	0	0	0	35
Insects	Spruce aphid	64	55	0	0	8
Insects	Spruce beetle[2]	145,322	1,190	15,096	35,724	93,312
Insects	Willow leafblotch miner	410	0	0	2	408
General Defoliation[3]	Aspen defoliation	72	31	0	0	42
General Defoliation[3]	Birch defoliation	854	0	22	0	832
General Defoliation[3]	Cottonwood defoliation	682	188	0	176	319
General Defoliation[3]	Hardwood defoliation	95	7	0	6	82
	TOTAL	**344,907**	**113,138**	**38,213**	**39,635**	**153,920**

[1] High-severity hemlock sawfly defoliation can result in tree mortality and topkill; therefore, surveyors distinguished between areas with light to moderate defoliation and areas with severe defoliation, where mortality is most likely to occur. The total hemlock sawfly damage acreage is presented separately to account for overlap between mortality and defoliation.
[2] The 2020 survey targeted areas known to have spruce beetle damage and included some infrequently surveyed areas affected in recent years. Typically, our surveys only document active mortality, but this year we aimed to capture the full outbreak extent in previously unsurveyed areas. Of the 145,332 total acres of mapped spruce beetle damage, 114,133 acres of forest were mapped as recent damage in 2020.
[3] General defoliation damage cannot be attributed to a particular agent because more than one agent is known to cause similar damage to the same host. Both insects and pathogens can cause defoliation.

Table 2. Mapped affected area (in thousands of acres) from 2016 to 2020 from aerial survey or aerial detection surveys. The 2020 replacement survey protocols varied from previous years, so direct data comparison is unadvisable.

Damage Type	2016	2017	2018	2019	2020
Abiotic damage	3.3	5.6	5.0	10.8	0.2
Alder defoliation	2.9	3.4	0.9	2.6	1.0
Alder dieback	8.4	1.0	3.2	1.2	0.0
Aspen defoliation	229.3	168.5	259.7	132.4	38.8
Aspen mortality	0.0	0.0	5.7	0.1	0.0
Birch defoliation	85.5	7.2	132.8	283.4	3.9
Cottonwood defoliation	2.3	1.0	3.6	1.7	0.7
Fir mortality	0.03	0.04	0.1	0.1	0.0
Hardwood defoliation	161.9	38.7	15	3.9	0.1
Hemlock defoliation	0.0	0.0	48.6	381	124.4
Hemlock mortality	0.0	2.7	0.1	0.0	80.0
Larch mortality	*	*	0.01	0.0	0.0
Porcupine damage	3.5	1.5	2.5	1.9	0.1
Shore pine damage	4.9	0.3	3.7	0.4	0.0
Spruce damage	36.2	36.1	2.5	117.8	0.7
Spruce mortality	204.5	411.4	594.3	140.6	145.3
Spruce/hemlock defoliation	3.1	1.1	4.2	0.0	0.0
Willow defoliation	156.3	113.2	39.9	32.7	0.5
Willow dieback	2.8	1.0	0.0	0.6	0.0
Yellow-cedar decline	39.3	47.4	17.7	20.0	10.4
Other damage	*	*	0.7	9.5	0.0
Total damage acres	**949.8**	**840.3**	**1139.9**	**1140.8**	**342.0**
Total acres surveyed	**26,876**	**27,540**	**27,954**	**24,421**	**7,322**
Percent of acres surveyed showing damage	**3.50%**	**3.05%**	**4.08%**	**4.67%**	**5.4%**

* not documented in previous reports

Table 3. Ground observations of forest insects and pathogens in Alaska in 2020. Cummulative ground observations by forest health professionals are displayed in our interactive Ground Survey Dashboard at https://arcg.is/1SH58a. Ground observations by citizen scientists can be found in The Alaska Forest Health Observations project on iNaturalist, accessed at https://www.inaturalist.org/projects/alaska-forest-health-observations and is decribed in greater detail on page 19.

Category	Damage Causing Agent	Scientific Names	Ground Observations*	iNaturalist Research Grade Observations**	Total
Insects	Adelgidae	Adelgidae spp.	24	0	24
Insects	Alder woolly sawfly	*Eriocampa ovata*	4	1	5
Insects	Amber-marked birch leafminer	*Profenusa thomsoni*	33	1	34
Insects	Aspen leafminer	*Phyllocnistis populiella*	90	13	103
Insects	Balsam woolly adelgid	*Adelges piceae*	1	0	1
Insects	Battered sallow	*Sunira verberata*	1	2	3
Insects	Birch aphid	*Euceraphis betulae*	39	1	40
Insects	Birch leafminer/roller	*Caloptilia* spp.	25	0	25
Insects	Birch leafroller	*Epinotia solandriana*	47	1	48
Insects	Cooley spruce gall adelgid	*Adelges cooleyi*	22	0	22
Insects	Cottonwood leaf beetle	*Chrysomela scripta*	5	0	5
Insects	Eriophyid mite	*Eriophyidae* spp.	81	6	87
Insects	Engraver beetles	*Ips* spp.	1	0	1
Insects	Gall midge	Cecidomyiidae spp.	10	3	13
Insects	Giant conifer aphid	*Cinara* spp.	2	0	2
Insects	Green alder sawfly	*Monsoma pulveratum*	14	1	15
Insects	Hemlock sawfly	*Neodiprion tsugae*	47	0	47
Insects	Hemlock woolly adelgid	*Adelges tsugae*	1	0	1
Insects	Larch sawfly	*Pristiphora erichsonii*	4	0	4
Insects	Late birch leaf edgeminer	*Heterarthrus nemoratus*	22	0	22
Insects	Leaf beetles spp.	Leaf beetles spp.	45	7	52
Insects	Rusty tussock moth	*Orgyia antigua*	14	32	46
Insects	Spotted tussock moth	*Lophocampa maculata*	2	37	39
Insects	Spruce aphid	*Elatobium abietinum*	11	0	11
Insects	Spruce beetle	*Dendroctonus rufipennis*	45	4	49
Insects	Spruce bud moth	*Zeiraphera canadensis*	6	0	6
Insects	Spruce budworm	*Choristoneura* spp.	4	0	4
Insects	Striped alder sawfly	*Hemichroa crocea*	1	0	1
Insects	Western blackheaded budworm	*Acleris gloverana*	24	3	27
Insects	Western tent caterpillar	*Malacosoma californicum*	2	7	9
Insects	Willow leafblotch miner	*Micrurapteryx salicifoliella*	62	1	63
Pathogens	Armillaria	*Armillaria* spp.	1	1	2
Pathogens	Aspen running canker	*Neodothiora populina*	8	0	8
Pathogens	Aspen target canker	*Cytospora notastroma*	3	0	3
Pathogens	Brown crumbly rot	*Fomitopsis pinicola*	23	0	23
Pathogens	Diplodia gall	*Diplodia tumefaciens*	9	2	11
Pathogens	Dothistroma needle blight	*Dothistroma septosporum*	1	0	1
Pathogens	Hemlock dwarf mistletoe	*Arceuthobium tsugense*	4	8	12
Pathogens	Spring spruce needle rust	*Chrysomyxa weirii*	13	8	21
Pathogens	Spruce broom rust	*Chrysomyxa arctostaphyli*	29	2	31
Pathogens	Spruce bud blights	Spruce bud blights spp.	19	0	19
Pathogens	Spruce bud rust	*Chrysomyxa woroninii*	6	1	7
Pathogens	Spruce needle cast	*Lophodermium piceae*	14	0	14
Pathogens	Summer spruce needle rust	*Chrysomyxa ledicola*	211	9	220
Pathogens	Western gall rust (on pine)	*Endocronartium harknessii*	71	0	71
Pathogens	Yellow cap fungus	*Pholiota* spp.	32	20	52

* "Ground Observations" are observations made by Forest Health Protection professionals in the field via direct observation, these include 20 minute timed meandors along the road system as well as opportunistic surveys.
** "iNaturalist Research Grade Observations" are observations reported by citizen scientists on iNaturalist that are identified to species and have 2/3rds community agreement in the taxonomic identification. While species-level IDs are typically needed to establish an observation as "research grade," observations can be deemed "research grade" at any taxonomic level below family, as long as the iNaturalist community votes that the observation does not need more specific IDs.

Figure 6. Bonanza Creek Long-Term Ecological Research program technician Karl Olson climbs a pole to remove shade cloth for the winter. The shade cloth experiment stresses young aspen trees to test the immune response system to the running aspen canker pathogen. USDA Forest Service photo by Lori Winton.

Partnerships are key to understanding the aspen running canker disease

The aspen running canker disease has recently been the focus of significant monitoring and research efforts in Alaska's boreal forest. Much of this work has been possible because of Forest Health Protection's (FHP) commitment to building partnerships to monitor the extent and impacts of damaging diseases, insects, and invasive plants. Aspen running canker was first discovered near Tok in 2014 as a result of a Forest Health Monitoring grant to the University of Alaska Fairbanks (UAF) Cooperative Alaska Forest Inventory (CAFI) program to improve insect and disease damage data collection on 600 continuously monitored permanent sample plots across 200 sites. Initiated in 1994, CAFI was the only long-term forest inventory program widely distributed across the boreal forest of Interior and Southcentral Alaska. CAFI conducted 5-year periodic inventories of the plots and maintained a comprehensive database of boreal forest conditions that spanned state and local governments, tribal, federal, and other land managers in Alaska.

When CAFI was defunded, the running aspen canker work was continued and expanded upon in 2016 with Dr. Roger Ruess, Director of the Bonanza Creek Long-Term Ecological Research (BNZ LTER) program (http://www.lter.uaf.edu/about), which is jointly managed by the UAF Institute of Arctic Biology and the USDA Forest Service Pacific Northwest Research Station. The BNZ LTER Regional Site Network was designed to understand the regional effects of climate-disturbance interactions (fire, permafrost thaw, insect/pathogen outbreaks) and consists of 118 permanent plot sites within the Ray Mountain, Tanana-Kuskokwim Lowland, and Yukon Tanana Upland ecoregions. The nationwide LTER network was created by the National Science Foundation in 1980 to provide scientific expertise, research platforms, and long-term datasets to document and analyze environmental change at 28 sites in the United States, Puerto Rico, French Polynesia, and Antarctica.

These partnerships have documented a steady increase in aspen mortality (about 7% per year) in Alaska since at least 2000. There has been speculation that the mortality has been caused by a persistent and widespread aspen leafminer outbreak that began around the same time. However, our studies have not found any evidence of insect-caused mortality. Instead, out of the 16,000 trees inventoried on 88 CAFI and LTER plots, we have seen direct evidence of canker-caused mortality on about 50% of the dead aspen trees inventoried. Cankers are lesions of dead phloem and cambium caused by an infectious pathogen; once a canker girdles a tree it will die. The plots were distributed within 7 ecoregions from the Yukon River to the Kenai Peninsula and east to the Canadian border. Overall, about 82% of the 88 plots had some amount of canker. We suspect these estimates are conservative because canker is difficult to diagnose in the upper canopy and in trees that have been dead for a long time.

A great challenge to diagnosing this disease has been the difficulty in identifying the causal agent. Despite repeated sampling and microscopic examinations, no evidence of bacteria, nematodes, insects, or fungal fruiting bodies have been found. In collaboration with Dr. Gerard Adams (University of Nebraska Lincoln), we endeavored to isolate the pathogen from diseased tissue and then artificially inoculated healthy aspen trees with candidate pathogens. By means of this technique we determined that the causal agent of aspen running canker is a fungus that is new to science. We worked with Dr. Pedro Crous (Westerdijk Fungal Biodiversity Institute, Utrecht, Netherlands) to taxonomically describe the new fungal species as *Neodothiora populina* Crous, G.C. Adams & Winton (Crous et al. 2020. Persoonia 45: 251-409).

By means of this technique, we determined that the causal agent of aspen running canker is a fungus that is new to science.

Our capstone studies of Alaska's aspen running canker outbreak are attempts to determine why young trees in young stands are apparently immune to infection, whereas young trees in intermediate-aged to mature stands are often dead and dying. Drs. Ursel Schuette and Mary Beth Leigh (UAF) are looking at gene transcription to investigate both fungal pathogenicity gene expression and tree defense gene expression. We also have a large replicated shade cloth experiment (Figure 6) in which young trees are carbon stressed and subsequently inoculated with the isolated pathogen to test whether tree immune response is elevated in those with a high relative growth rate.

By Loretta Winton, Plant Pathologist with the USDA Forest Service Alaska Region, Forest Health Protection.

Kenai Peninsula invasive European bird cherry tree program 2020

In the spring of 2020, the Kenai Peninsula Cooperative Invasive Species Management Area (KP-CISMA) launched a new program focused on surveying, building awareness, and implementing control of the invasive European bird cherry (*Prunus padus*) (Figure 7 and Figure 8) and chokecherry (*Prunus virginiana*) trees throughout the Kenai Peninsula and across Kachemak Bay. What began as a peninsula-wide survey spearheaded by Homer Soil and Water Conservation District (HSWCD) and Kenai Watershed Forum (KWF), quickly evolved into a pilot cost-share program launched by HSWCD for local landowners. HSWCD offered a $100 reimbursement for purchasing alternative ornamental trees and shrubs if the landowner removed all of the invasive *Prunus* trees from their property (Figure 9). After social media campaigns, presentations to community organizations, and radio programs helped spread the word, the public narrative around European bird cherry trees shifted from "I love these trees and they don't seem to be spreading" to "What? This is invasive? How do I get rid of it?" Many landowners reported seeing extensive growth, aggressive suckering, and seedling flushes of *Prunus* trees within the last five years and were grateful to receive advice on how to kill the roots. Many landowners were not interested in the $100 reimbursement but instead desired herbicide assistance, and thus HSWCD offered a cut-stump herbicide application to those who cut down their own trees. Meanwhile, the Alaska Food Hub and Homer Farmers Market were contacted by concerned citizens because European bird cherry trees were for sale in these markets. After pressure from the public, the seller removed the tree from the Alaska Food Hub, and the Farmers Market is considering a policy that prohibits the sale of invasive plants. To capitalize on the momentum of public dialogue, the KP-CISMA pursued additional funding through an Alaska Department of Natural Resources Division of Forestry (DNR DOF) grant to offer more extensive landowner assistance in tree removal.

Meanwhile, the peninsula-wide survey was yielding evidence that *Prunus padus* trees have spread aggressively, escaping from lawns, inhabiting neighborhood creeks, and spreading into remote areas – likely by birds. A standard survey form was developed in the Arc Collector app, which allowed KP-CISMA partners to update and view survey data in real-time on ArcGIS online maps. Partners reported trees found while venturing into the field for a variety of work all summer long, and members of the public reported dense neighborhood infestations. HSWCD was contacted with stories of landowners plucking 70+ seedlings from their lawn, introduced from mother trees on adjacent properties. Overall, 650 infestations were observed peninsula-wide and across Kachemak Bay, and just under 2,000 trees were recorded (Map 5). The Kenai/Soldotna urban area was not

Figure 7. European bird cherry tree competing with native trees and shrubs along a neighborhood creek on Homer Bench. Courtesy photo by Katherine Schake.

Figure 8. Spring photo of a local property heavily infested with European bird cherry trees, which were planted over 20 years ago. Courtesy photo by Katherine Schake.

Figure 9. After removal assistance by Homer Soil & Water and local contractors. Efforts like this reduce the amount of cherries that birds transport to vulnerable habitat that support local wildlife. Courtesy photo by Katherine Schake.

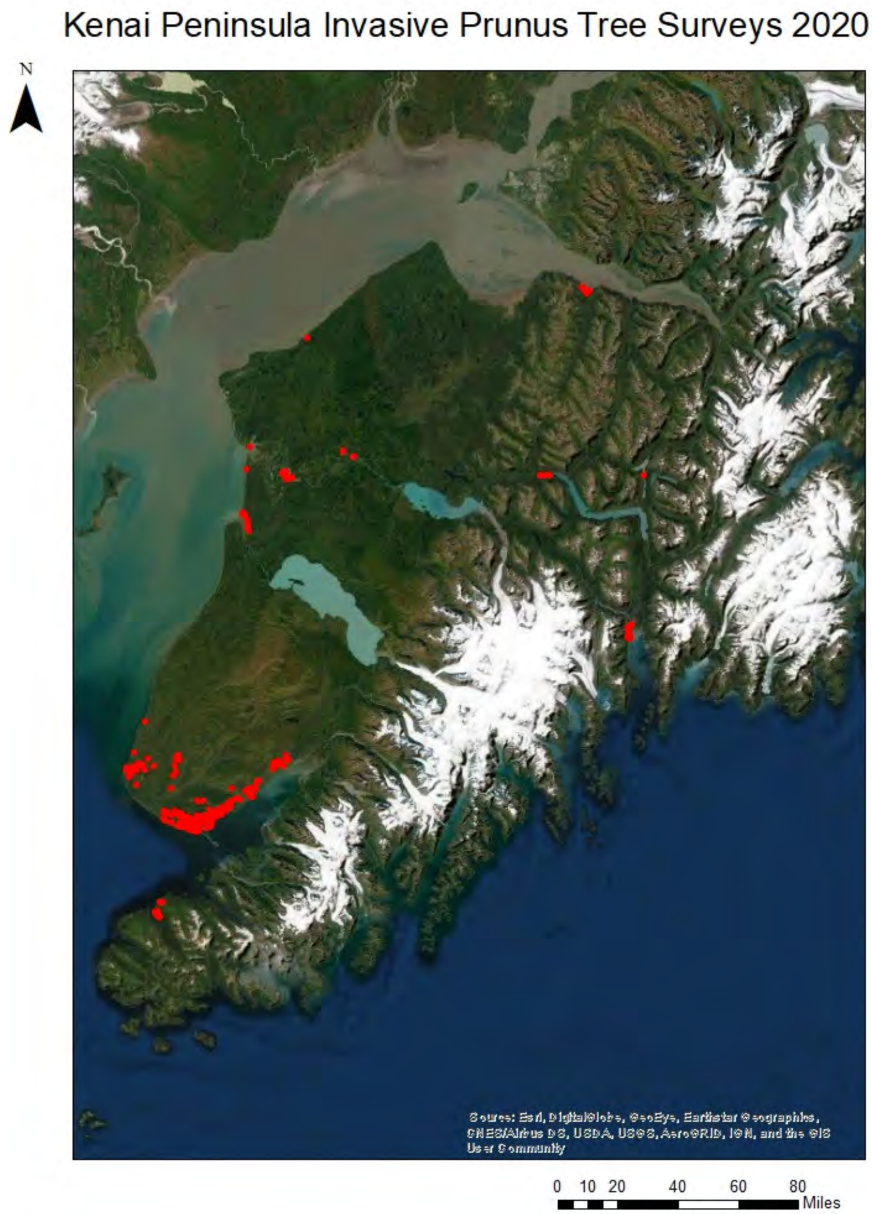
extensively surveyed due to the high density of *Prunus* trees and limited capacity of the program.

Analysis of survey data revealed 640 infestations within the lowland wetlands habitat and surface streams of the peninsula, which are identified as critical salmon habitat by the Kenai Peninsula Fish Habitat Partnership. Twenty-three of the infestations are within 550 feet of managed salmon streams, and 219 infestations are within 500 feet of public lands on the Kenai Peninsula.

Because the KP-CISMA's main goal this summer was to reduce the amount of cherries being spread by birds while increasing public awareness around invasive *Prunus* trees, we did not discriminate on the type of removal assistance provided to landowners (Figure 10). Only those who cut down their own trees were eligible for the $100 cost-share program, but we were able to use a variety of grant funds (US Fish and Wildlife Service, Copper River Watershed Project Mini-Grant, and DNR DOF) to support tree cutting, herbicide work, mulching, and limb disposal on multiple properties. By October, over 27 people had participated, resulting in removal of approximately 90 European bird cherry and chokecherry trees, greatly reducing the amount of cherries adjacent to vulnerable habitat such as creeks and wetlands in local neighborhoods, at the head of Kachemak Bay, and along McNeil Canyon. Landowners contributed over $5,200 of in-kind contributions and cash match.

While the urban areas of the Kenai Peninsula are beyond an early detection and rapid response management approach for European bird cherry trees, there is still time to prevent the spread into adjacent natural landscapes. Thanks to this program, the KP-CISMA now understands that invasive *Prunus* trees are indeed spreading outward from residential yards and competing with native vegetation – the building blocks of our ecosystems that support fish and wildlife. Next year we will prioritize removal of trees based on density of known infestations and proximity to valuable salmon and moose habitat. Thanks to funding from the Forest Service and DNR DOF, we will continue removal efforts with a focus on public lands in 2021.

By Katherine Schake, Homer Soil & Water Conservation District & KP-CISMA Coordinator.



Map 5. Kenai Peninsula *Prunus* survey data collected by Maura Schumacher (KWF), Katherine Schake (HSWCD), and KP-CISMA partners. Map created by Katherine Schake.

Figure 10. Removal techniques and landowner contributions to the program have been varied. Courtesy photo by Casey Greenstein.

Hemlock sawfly in Southeast Alaska: monitoring a large-scale defoliation event with an interdisciplinary approach

Hemlock sawflies are native defoliators of western hemlock, with outbreaks recorded periodically in Southeast Alaska. The larvae feed on older foliage, typically leaving the new growth untouched (Figure 11) . Under outbreak conditions all age classes of western hemlock are affected, and larvae may also feed on other nearby conifers, such as mountain hemlock and Sitka spruce (Figure 12). Damage is often greatest on warmer, drier sites with western and southern exposure or along ravines, with repeated years of defoliation sometimes resulting in mortality. Hemlock sawfly larval populations are affected by specific environmental conditions, such as cool, wet summers, which are conducive to the growth of entomopathogenic fungi that infect the larvae and keep their populations in check.

The most recent outbreak was first noted in 2018 by members of the public living on Killisnoo Island, following a drier than average summer. Their observation initiated aerial surveys over the area to record the extent of the damage. In 2019, ground surveys were conducted throughout Southeast Alaska to assess the larval population and the amount of damage. The outbreak increased in severity as drought conditions continued, with more than 380,000 acres of hemlock sawfly defoliation recorded in 2019 during aerial surveys. Due to the limited number of aerial surveyors and flight permissible days, it is impossible to survey the entire forest and ascertain the full extent of an outbreak. On the other hand, satellite-based remote sensing has the potential to extend detection of forest change over greater area.

Forest Health Protection began a collaboration with the Kennedy Lab at Oregon State University in 2019 to develop remote sensing methods to better estimate the total area affected by the hemlock sawfly outbreak. This project was very timely because in 2020 our ability to quantify the damage was severely restricted due to the COVID-19 pandemic as all aerial surveys and travel for fieldwork were canceled. To adequately report on the status of the hemlock sawfly outbreak, Forest Health Protection relied on various resources, including support from Tongass National Forest district staff and new remote sensing technologies to collect this valuable information.

Figure 11. Hemlock sawfly larvae were still present throughout the Tongass National Forest but in much lower numbers than in 2018 and 2019. USDA Forest Service photo by Elizabeth Graham.

Figure 12. Hemlock sawfly defoliation was striking during the 2019 aerial detection survey. Over 300,000 acres of damage was recorded in 2019. Aerial surveys were not conducted in 2020, however damage was still apparent on satellite imagery. USDA Forest Service photo by Elizabeth Graham.

Early season egg survey

Western hemlock branches were sampled for evidence of hemlock sawfly eggs (Figure 13) on June 5, 2020 at seven locations along the road system in Juneau, AK. Areas where measurable defoliation was detected in previous years were systematically revisited to determine the likelihood of the outbreak continuing, as well as its severity, using the techniques described in Hard 1971. All seven locations showed a moderate to heavy population index (Figure 14).

Figure 13. Hemlock sawfly egg site on a western hemlock needle. USDA Forest Service photo by Elizabeth Graham.

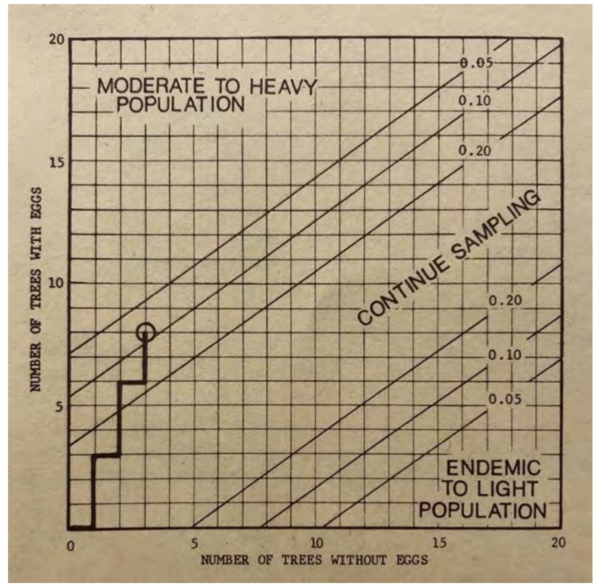


Figure 14. Intermediate crown class hemlock trees were selected at random and relieved of a branch, which was then examined until an egg was found or not. A two-level classification graph was referenced and trees were sampled sequentially until a decision line was crossed. Graph from Hard 1971.

Ground survey

The tree species, size class, amount of defoliation, defoliator species, and the number of each species sampled were recorded at 68 sites across the Tongass National Forest during July and August 2020. Ground surveys were conducted by Tongass National Forest District staff when they were able to fit the surveys into their workload, resulting in the survey being conducted at varied times. At each site, a minimum of 10 trees were sampled for defoliators using a beating sheet (Figure 15). A total of 505 trees were sampled at 49 sites across the Tongass National Forest thanks to our partners on the Petersburg, Wrangell, Ketchikan, Prince of Wales, and Sitka Ranger Districts.

Figure 15. Silviculturist Craig Buehler sampling for hemlock sawfly larvae on the Petersburg Ranger District. District staff across the Tongass National Forest assisted with the survey in their area due to COVID-19 travel restrictions. USDA Forest Service photo by Karen Dillman.

Overall, hemlock sawfly activity decreased dramatically across the region but hemlock sawfly remained the most common defoliator species collected. Hemlock sawfly larvae were recorded at 72% of the sites but only on 12.5% of the trees. In most cases (85.7% of the time), the number of larvae collected was low (<4 per beating sheet). Active defoliation was rated moderate to severe in only 14.7% of the locations surveyed. Top-kill or mortality related to defoliation was recorded at 5.9% of sites (located on Juneau, Petersburg, Wrangell, and Ketchikan Ranger Districts).

Western blackheaded budworm was the only other defoliator recorded with regularity (49% of sites) at low to moderate levels. Western blackheaded budworm feed on new hemlock foliage, which, when coupled with hemlock sawfly defoliation, could be detrimental to tree health.

Other observations
As of 2020, hemlock sawfly larvae were reported to be active on Killisnoo Island for the third year in a row. Residents reported larvae as well as frass falling from the canopy; however, at lower levels than in previous years. Dead or dying hemlock were observed throughout Killisnoo Island as well as the coastline and bays surrounding Angoon on Admiralty Island, the Staney area of Prince of Wales Island (Figure 16), and the Peterson Creek and Eagle River drainages in Juneau. All age classes were affected by sawfly feeding, however trees with exposed canopies sustained the most damage and mortality was greatest in high-density hemlock stands on warmer and drier sites. In heavily impacted areas, feeding damage could be seen throughout the entire tree.


Figure 16. Western hemlock killed after repeated years of defoliation by hemlock sawfly in the Staney Creek area of Prince Of Wales Island. USDA Forest Service photo by Molly Simonson.

Scan and Sketch
Hemlock sawfly damage was detected on over 143,000 acres using the scan and sketch survey method (see Appendix 1 on page 66). High-resolution imagery observations showed heavy impact from 2019 as well as continued defoliation in the Juneau area and on Douglas, Etolin, Zarembo, Woronkofski, and Wrangell Islands, with entire hillsides impacted (Figure 17, page 18). Mortality attributed to sawfly damage was recorded on over 80,000 acres, most of which was on Prince of Wales Island, which had good imagery coverage, allowing surveyors to distinguish between defoliation and mortality. Often defoliation and mortality were recorded in the same area, therefore the total area impacted by hemlock sawfly was over 143,000 acres.

Remote sensing effort
The most all-encompassing forest change detection was accomplished using Landsat satellite imagery with the LandTrendr algorithm and BugNet script in the Google Earth Engine (GEE) processing platform. Landsat captures the entirety of Alaska every 8 days with a resolution of 30 m. The Landsat signature for hemlock sawfly defoliation was identified using a combination of ADS data and LandTrendr detected change; pre- and post-damage spectral values were then sorted with the Random Forest statistical tool in GEE (Figure 18, page 18). This knowledge was applied to model hemlock sawfly damage across Southeast Alaska for 2018, 2019, and 2020. During overcast summers (e.g., 2017 and 2020) it can be challenging to obtain cloud-free images to detect change everywhere. To overcome some of these issues and provide the best representation of forest damage, a cumulative map of hemlock sawfly damage for 2018-2020 was created (Map 6, page 18), estimating the total area impacted was to be almost 650,000 acres. The west side of Admiralty Island had the highest concentration of change, especially near Hawk Inlet and Angoon and Killisnoo Island, where the first reports of hemlock sawfly defoliation were reported. Kuiu, Kupreanof, Mitkof, and northern Prince of Wales Islands also showed high levels of change. While the total area will always depend on the methods and model parameters used, these methods produced a conservative, but representative, quantification of the area affected by current hemlock sawfly outbreak.

Conclusion
The data presented here represents an interdisciplinary approach to monitoring an insect outbreak; no one method is all-encompassing and can tell the entire story on its own. Reports from the public can help guide surveyors to where outbreaks are happening. Ground surveys are crucial for identifying the damage agent and assessing severity. Aerial surveys provide a larger perspective of the damage area but are limited by the weather conditions, risk, and other inherent challenges of flying. Remote sensing techniques can provide an even larger scale view of change, but the technology is still being developed and detection is constrained by the quality of the imagery and the severity, extent, and percent cover of the damage. The hemlock sawfly outbreak has provided an opportunity to combine all these techniques to try to get a complete picture of the outbreak. The ground and aerial surveys have helped to create and verify the model used in the LandTrendr analysis. This interdisciplinary approach involving entomologists, programmers, aerial surveyors, foresters, and the public, has demonstrated that the hemlock sawfly outbreak that was first reported in 2018 and continued through 2020 has resulted in damage affecting 650,000 acres. Mortality has occurred in several areas and is expected to become more apparent in 2021; however, hemlock sawfly activity is not expected to persist. The cool, wet summer weather conditions in 2020 were not conducive to larval development and larval counts were subsequently low throughout most of the region. The practices used to quantify and describe the hemlock sawfly outbreak could be applied to other major mortality and defoliation events.

By Dr. Elizabeth Graham, Entomologist, and Dr. Karen Hutten, Aerial Survey Program Manager with the USDA Forest Service Alaska Region, Forest Health Protection.

The Forest Health Protection Team would like to thank and acknowledge the following for their help and observations that made this report possible: Isaac Davis, Isaac Dell, Mary and Gordy McDowell, Robert Kennedy, Peter Clary, and Justin Braaten at Oregon State University, and the Tongass National Forest Staff (Craig Buehler, Karen Dillman, Tom Heutte, Paula Rak, Kat Reynolds, Tom Roland, Molly Simonson, TJ Witherspoon, and Janice Sangunitto).

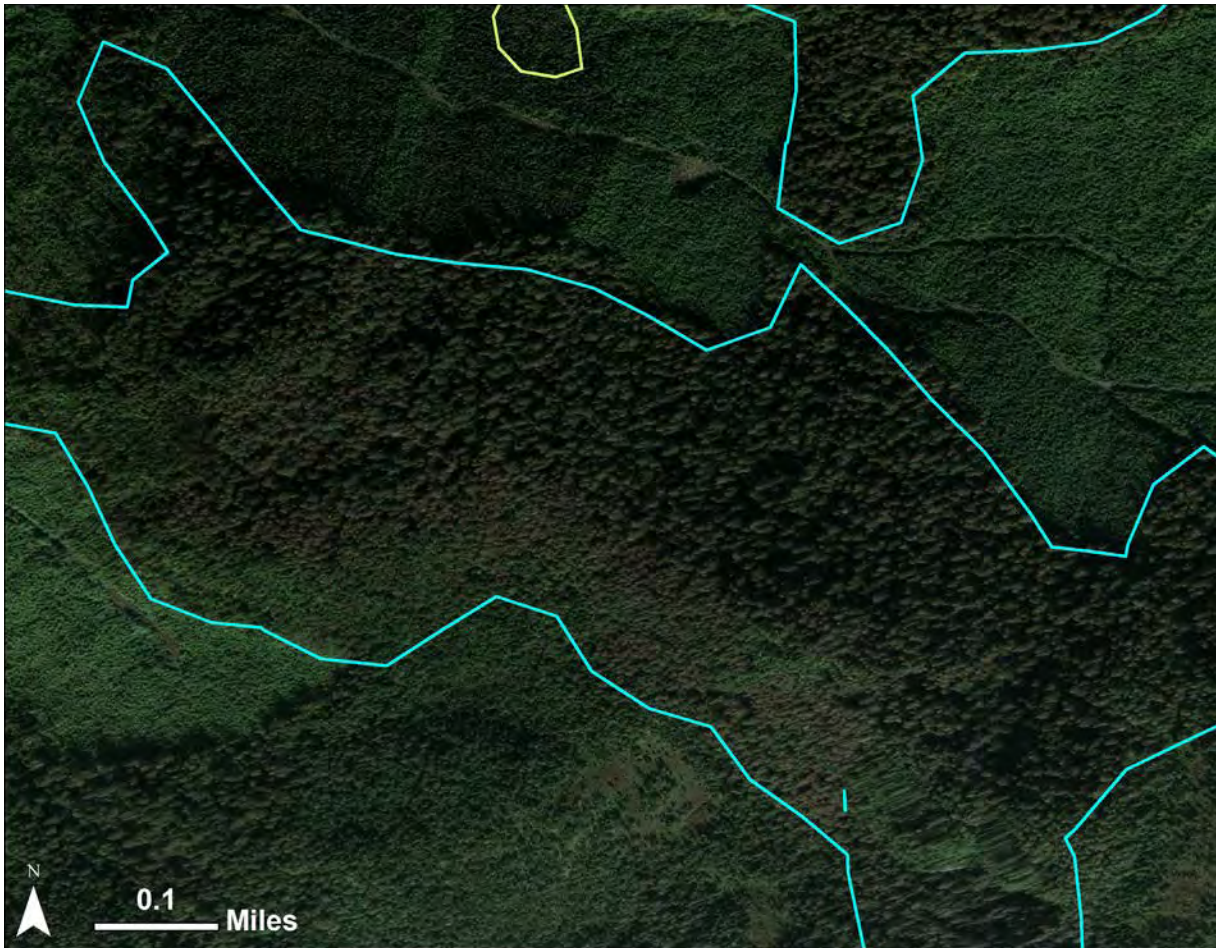


Figure 17. Blue polygon delineating hemlock sawfly damage drawn during scan and sketch surveys.

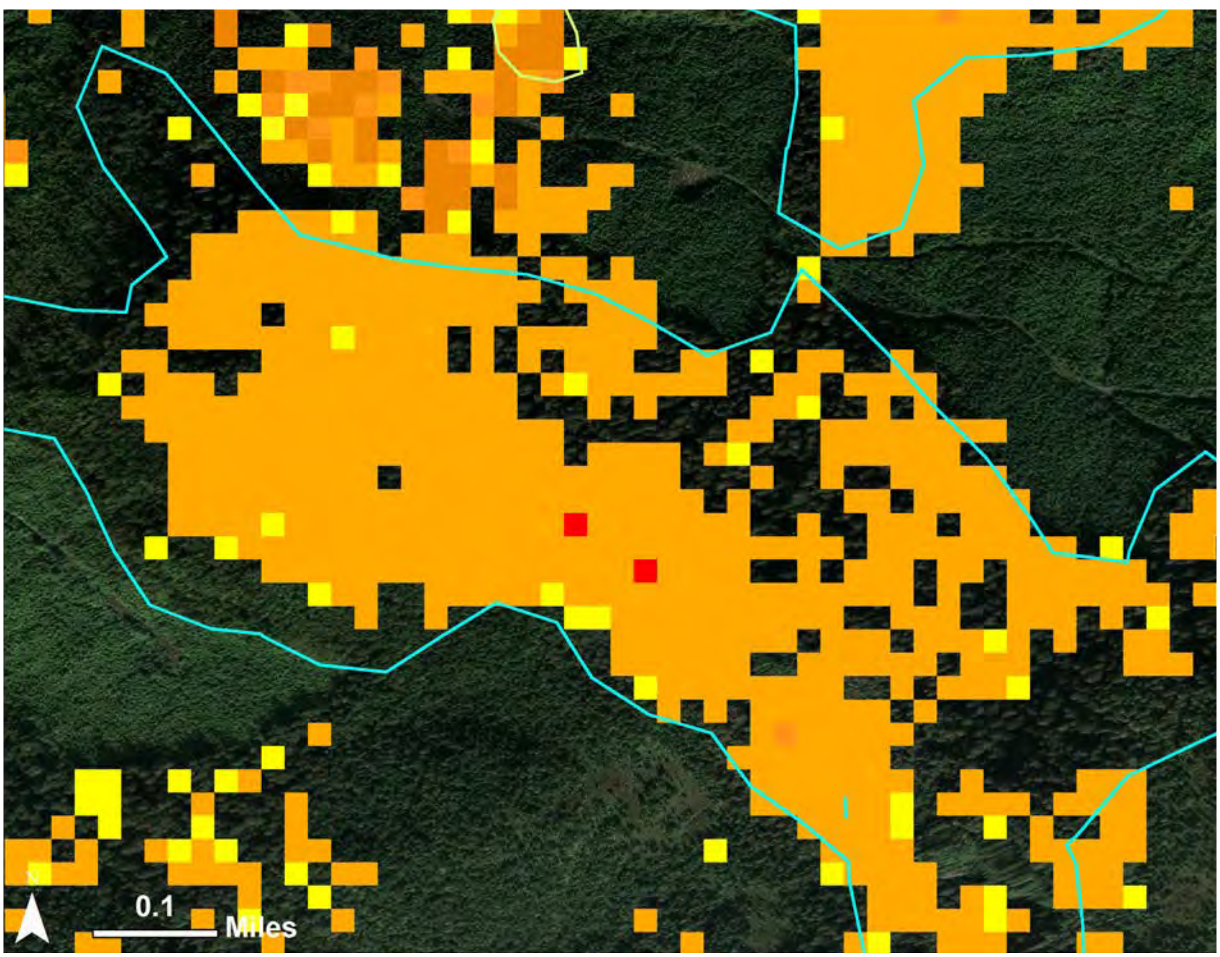
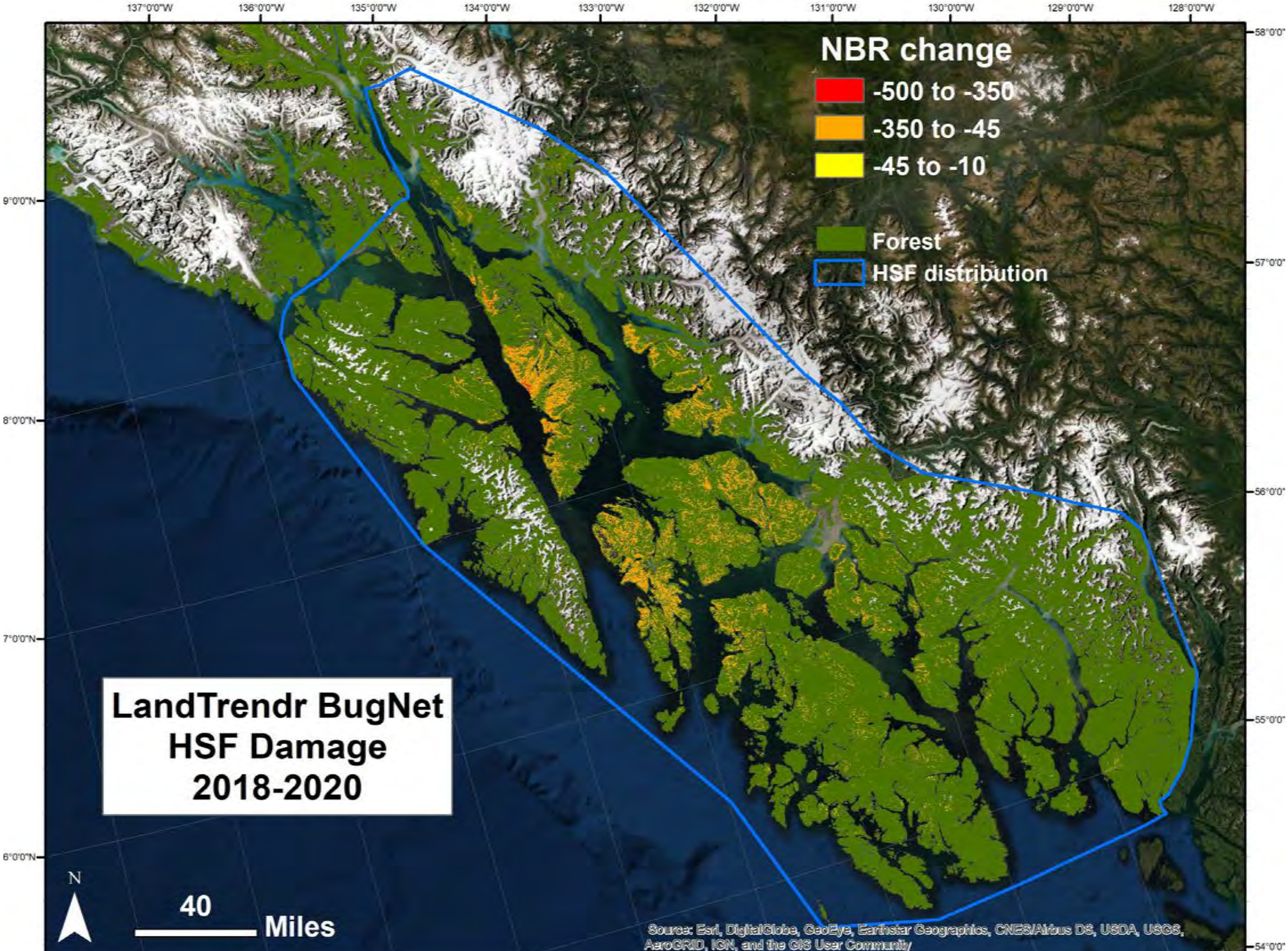


Figure 18. Results from LandTrendr analysis, showing low (yellow), medium (orange), and high (red) magnitude of change related to hemlock sawfly defoliation.



Map 6. Cumulative hemlock sawfly damage from 2018 to 2020. Normalized Burn-Ratio (NBR) values correspond to the magnitude of reflectance change, with higher change values signifying more severe defoliation.

Crowd-sourcing forest pest observations: creative ways to monitor forest health during a pandemic

This year, we established a citizen science project on iNaturalist, a social media platform that allows users to upload biotic observations, called “Alaska Forest Health Observations.” Within this project, we have established a broad range of taxa that impact forest health, which also includes organisms that our Forest Health Protection team does not generally report on during ground and aerial surveys (e.g., Siricidae (Horntails)). Through this project, we can tap into data that citizen scientists in Alaska are already uploading from their backyards, roadsides, trails, remote islands, and even in National Parks and Forests. Additionally, through call-to-action posts on the “U.S. Forest Service–Tongass National Forest” and the “U.S. Forest Service–Chugach National Forest” pages on Facebook, as well as the "Alaska Region" (@AKForestService), “Chugach Natl Forest” (@ChugachForestAK), and “Tongass Nat’l Forest” (@TongassNF) handles on Twitter, we can encourage those interested in becoming forest health citizen scientists to participate in this project. We will continue to use this crowdsourced dataset to rapidly assess where forest damage agents have been observed, where outbreaks may be building, and to keep a finger on the pulse of forest health concerns of the public. For example, some of these iNaturalist observations have helped us identify the possible range expansion of the western tent caterpillar into Southeast Alaska (see Insect Updates on page 52). Remarkably, between April and December 2020, 312 users uploaded 2,471 forest health observations of 217 different species in Alaska to our Alaska Forest Health Project in iNaturalist (Figure 19).

For the purposes of this project, the term “citizen scientist” refers to those who are not working in a professional capacity for the Forest Service’s, Forest Health Protection team. As such, when summing the numbers of iNaturalist observations herein, we have omitted those made by Forest Health Protection staff.

iNaturalist features an algorithm to assess the overall data quality of a given observation. An observation that is verifiable (i.e., has a date, GPS coordinates, photo(s), and is an organism that is not captive or cultivated) but lacks a taxonomic ID that has two-thirds agreement by iNaturalist users, is labeled “Needs ID.” On the other hand, an observation that is verifiable and has two-thirds community agreement on a taxonomic ID is labeled “Research Grade.” Observations that meet none of those of those criteria are labeled “Casual.” Within our Alaska Forest Health Observations iNaturalist project, all observations to date are either considered “Research Grade” or “Needs ID,” with 1,102 and 1,369 such observations, respectively. Of those, citizen scientists have reported 198 “Research Grade” observations and 134 “Needs ID” observations of insect defoliation. Furthermore, 22 “Research Grade” and 34 “Needs ID” observations of pathogens were made, which included observations of rusts, galls, and fungi. Additional observations included species that we do not routinely monitor for, such as the Lepturinae, the flower longhorn beetles. To view the iNaturalist observations by damage agent see Table 3 on page 10.

By Dr. Sydney Brannoch, Entomologist, USDA Forest Service, Alaska Region, Forest Health Protection.

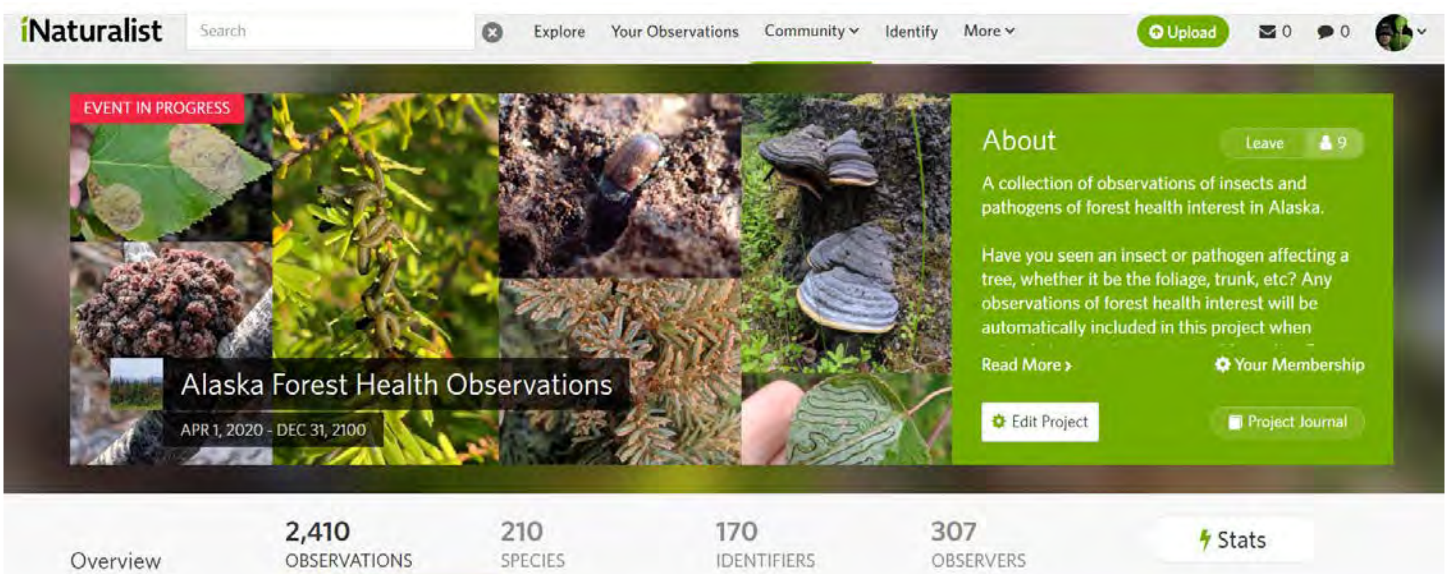
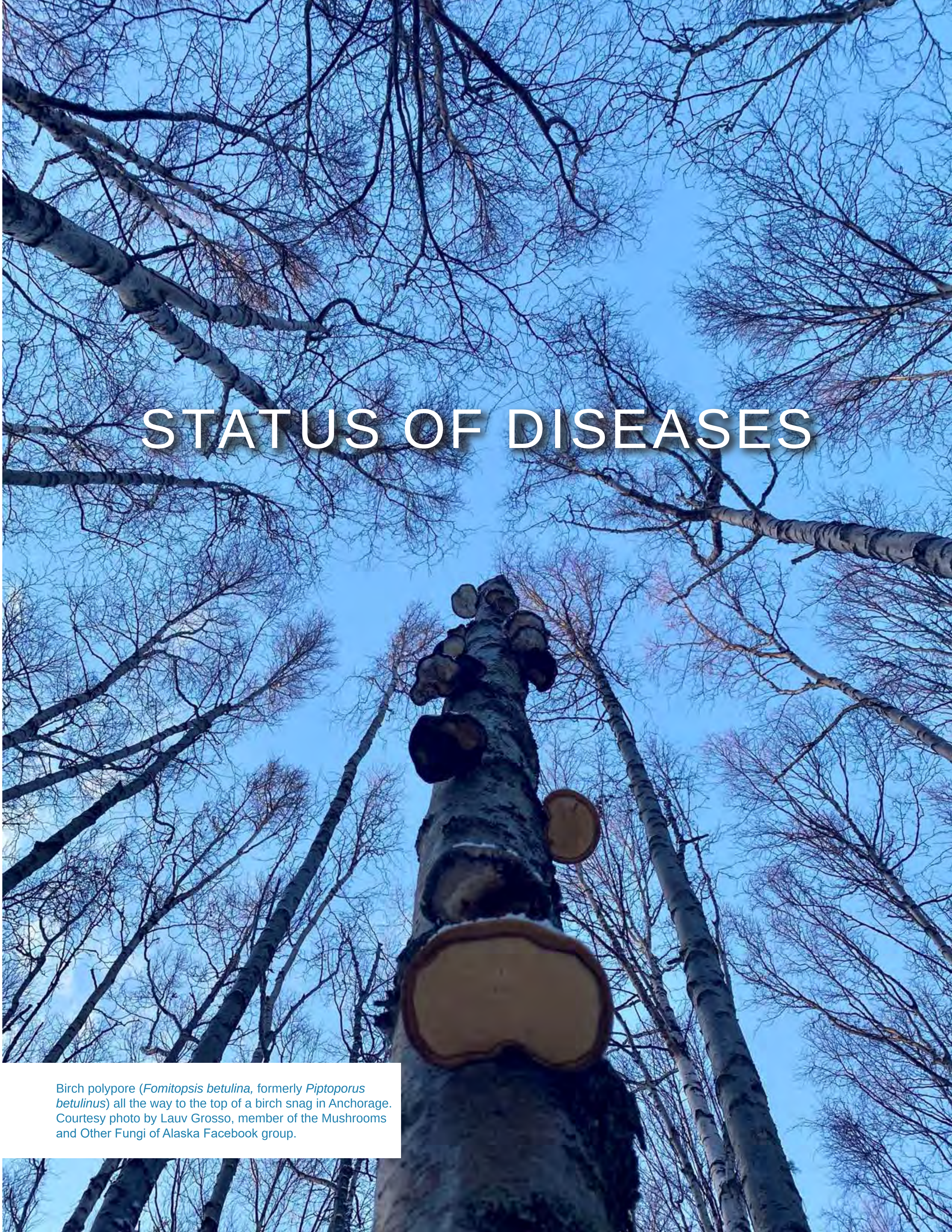


Figure 19. Screenshot of our “Alaska Forest Health Observations” dashboard in iNaturalist (available from https://www.inaturalist.org, accessed 12/10/20). This project, which was established in April 2020, enabled us to engage with the public on forest health issues affecting our state.

STATUS OF DISEASES



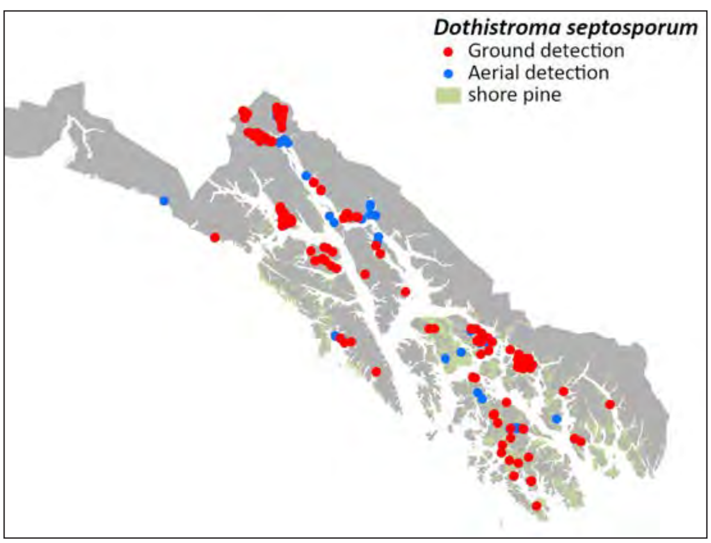
Birch polypore (*Fomitopsis betulina,* formerly *Piptoporus betulinus*) all the way to the top of a birch snag in Anchorage. Courtesy photo by Lauv Grosso, member of the Mushrooms and Other Fungi of Alaska Facebook group.

2020 PATHOLOGY SPECIES UPDATES

Foliar Diseases

Dothistroma Needle Blight
Dothistroma septosporum (Dorog.) M. Morelet

Damage from Dothistroma needle blight was notably reduced in 2020, even in areas with abundant shore pine that typically have moderate to severe disease (Pt. Bridget State Park and Douglas Island). The dry weather in 2018 and 2019 inhibited disease spread. Although precipitation was far above average in 2020, temperatures were lower than optimal for the pathogen. Consecutive rainy days and temperatures > 62°F are known to cause Dothistroma outbreaks; therefore, deadly outbreaks are strongly linked to climate trends (as has been well-documented in lodgepole pine forests in British Columbia). This disease occurs throughout the range of shore pine in Alaska (Map 7). An outbreak near Gustavus, AK in 2010-2016 killed 57% of shore pine and left dominant trees with foliage only in the upper 1-3 ft of tree crowns in monitoring plots in heavily affected forests. Preliminary results from a genomics study of the pathogen across western North America conducted by Dr. Renate Heinzelmann (University of British Columbia) suggest that the Gustavus population of *Dothistroma septosporum* is more closely related to populations in British Columbia than to all other populations in Southeast Alaska.

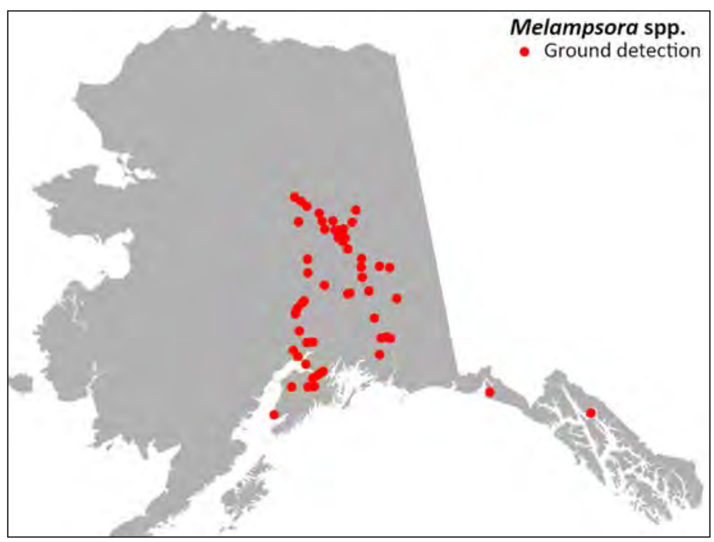


Map 7. Dothistroma needle blight cumulative mapped locations and modeled host tree distribution(s).

Hardwood Leaf Rusts
Melampsora epitea Thuem.
Melampsora medusae Thuem.
Melampsoridium betulinum Kleb

Moderate hardwood leaf damage was common on birch and willow in Interior Alaska and on willow in Southeast Alaska in 2020, with 61 records on willow and 15 on birch. Near Salcha, birch leaf rust damage (Figure 20) coincided with very heavy defoliation from birch aphid. Several hardwood leaf rust fungi infect the leaves of hardwood trees and shrubs throughout Alaska (Map 8). Orange spores are produced on the undersides of leaves in late summer. Affected birch, cottonwood, and willow display yellow to brown discoloration of leaves or entire tree or shrub crowns.

Figure 20. Birch leaf rust (*Melampsoridium betulinum*) along Chena Hotsprings Road in 2020. USDA Forest Service photo.



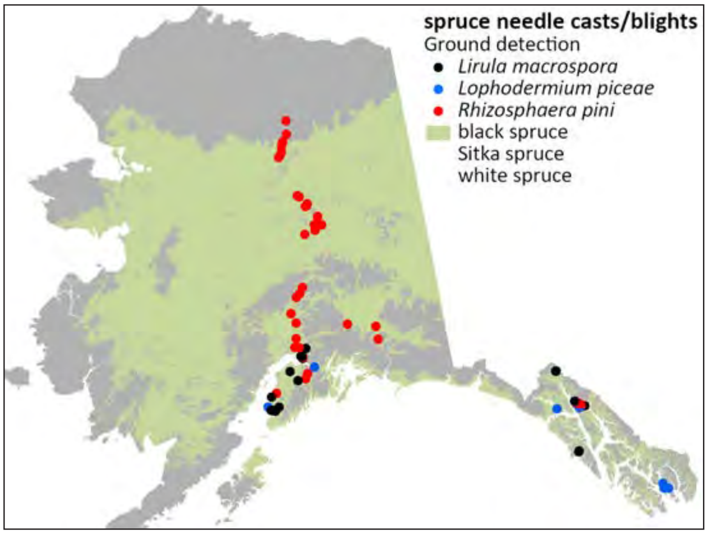
Map 8. Hardwood leaf rusts cumulative mapped locations. Host tree and shrub distributions are not shown, but include willow, birch, aspen, and cottonwood.

Hemlock-Blueberry Rust

Naohidemyces vaccinii (Wint.) Sato, Katsuy et Hiratsuka

Hemlock-blueberry rust is usually a disease of minor importance that can be difficult to find on both blueberry leaves and hemlock needles. However, in 2019 and 2020 this disease was widespread on multiple blueberry species and western hemlock needles in Southeast Alaska (Figure 21). Infected needles were collected this year at several sites near Juneau to allow for molecular verification of the causal fungus.

Figure 21. Hemlock-blueberry rust on western hemlock needles (left) and oval-leafed blueberry (right). USDA Forest Service photo by Robin Mulvey.



Spruce Needle Casts/Blights

Lirula macrospora (Hartig) Darker
Lophodermium piceae (Fuckel) Höhn
Rhizosphaera pini (Corda) Maubl.

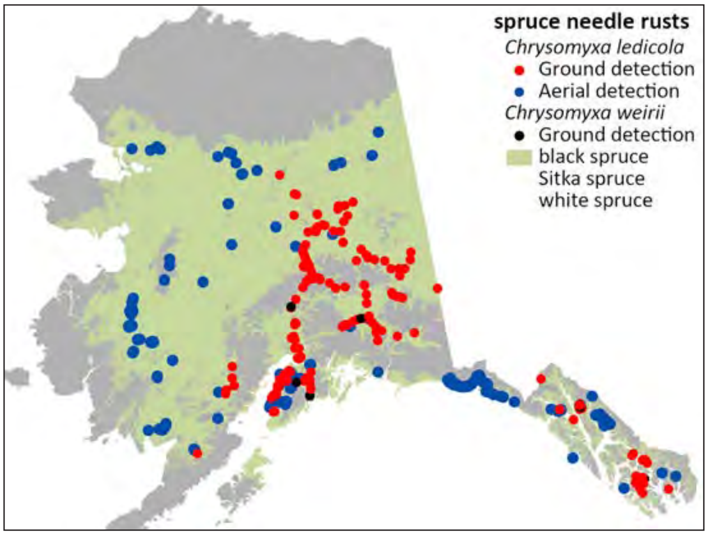
Three fungi cause needle blight of spruce throughout much of Alaska (Map 9). Rhizosphaera needle blight damage of Sitka spruce near Juneau was elevated in 2019 but returned to normal levels in 2020. Lirula needle blight was the most dominant spruce needle blight detected in 2020. Lophodermium needle cast is another common but minor foliage disease of spruce in Alaska.

Map 9. Spruce needle casts/blights cumulative mapped locations and modeled host tree distribution(s).

Spruce Needle Rusts

Chrysomyxa ledicola Lagerh.
C. weirii Jacks.

Spruce needle rust (*Chrysomyxa ledicola*) has historically been observed throughout much of Alaska's spruce forests (Map 10). A major outbreak was aerially mapped across 116,000 acres in Western Alaska in 2019. The disease was also prevalent in 2020 but was not quantified by aerial survey. Ground surveys identified about 600 acres of damage near the junction of the Parks and Denali Highways. In addition, 86 ground observations came from FHP staff, while citizen scientists uploaded 15 research grade observations of the disease in iNaturalist. There was especially impressive damage along the Denali Highway and in Southeast Alaska near muskegs with the alternate host (Labrador tea) (Figure 22). This disease rarely results in tree mortality, but trees can have whole needle cohorts missing where disease has been severe. Moderate to high levels of disease have been noted annually since 2017. *Chrysomyxa weirii* causes another less common and damaging spruce needle rust in Alaska that occurs on one-year-old-needles in spring.



Map 10. Spruce needle rust cumulative mapped locations and modeled host tree distribution(s).

Figure 22. Spruce needle rust (*Chrysomyxa ledicola*) sporulating on Labrador tea leaves. USDA Forest Service photo by Robin Mulvey.

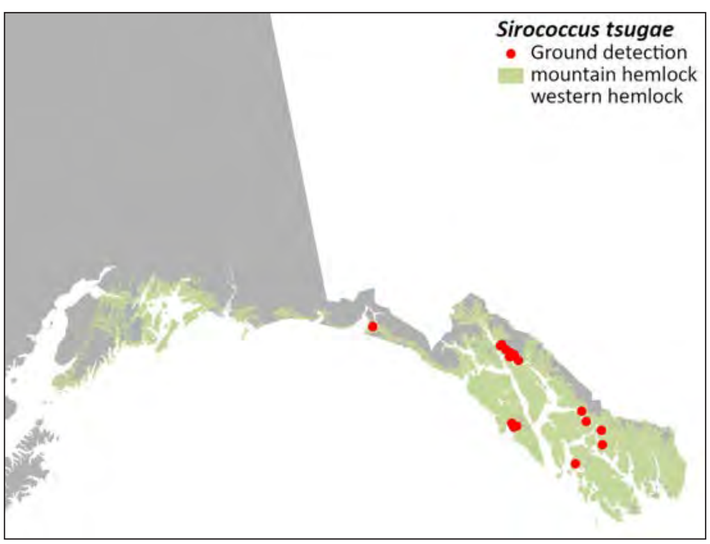
Shoot, Twig, and Bud Diseases

Sirococcus Shoot Blight

Sirococcus tsugae Rossman, Castlebury, D.F. Farr, & Stanosz

Sirococcus shoot blight activity was more pronounced near Juneau in 2020 (Figure 23) than in a decade or more. It is expected that the disease was also widespread in unsurveyed areas throughout the Panhandle. The causal fungus, which kills shoots of western and mountain hemlocks and occasionally spruce in Southeast Alaska (Map 11), benefits from the cool, wet conditions that were common this year. Sirococcus damage was negligible in 2019 following a second year of drought. Hemlocks with evidence of repeated years of shoot dieback and compromised tree form are most often found along creeks and in mountain bowls. Chronic shoot disease observed in landscape plantings suggests that non-native hemlock varieties may be more susceptible to this disease than hosts in natural settings.

Figure 23. Sirococcus shoot blight (*Sirococcus tsugae*) on western hemlock. USDA Forest Service photo by Robin Mulvey.

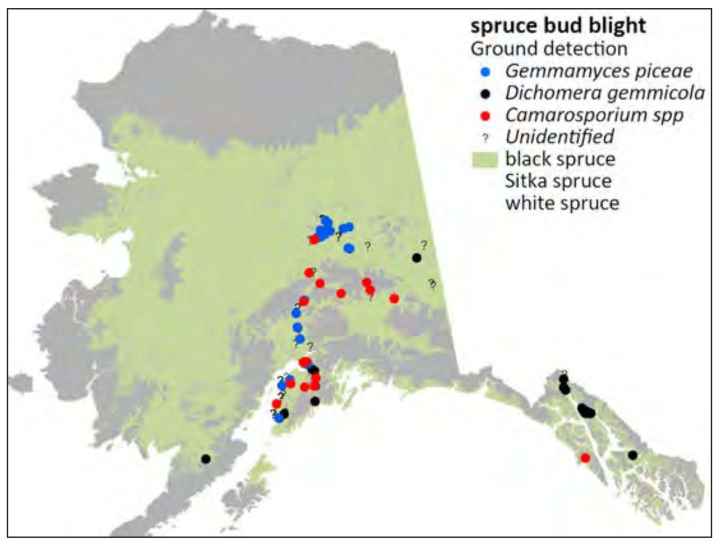


Map 11. Sirococcus shoot blight cumulative mapped locations and modeled host tree distribution(s).

Spruce Bud Blights

Camarosporium sp.
Dichomera gemmicola A. Funk & B. Sutton
Gemmamyces piceae (Borthw.) Casagrande

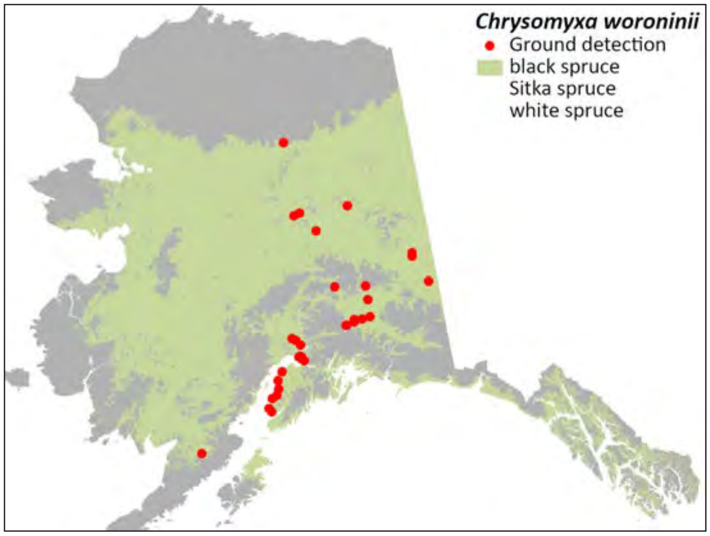
We continued to document spruce bud blight throughout Southcentral and Interior Alaska (Map 12). We found nine instances of *Gemmamyces piceae* south of the Alaska Range and one occurrence to the north near Delta Junction. *Dichomera gemmicola* was found in three locations south of Anchorage and a single *Camarosporium* occurrence was found along the Denali Highway. Five bud blight sightings are unidentified because they were not collected for microscopic verification of the causal fungus. No bud blight was detected in Southeast Alaska in 2019 or 2020, consistent with apparently lower disease incidence and severity. None of these fungi had previously been reported from Alaska prior to 2013, although *D. gemmicola* and *Camarosporium* have been known for decades in other parts of North America. *Gemmamyces piceae* is known as a tree killer in Colorado blue spruce plantations in Central Europe, but we have not seen mortality in Alaska. We have sequenced the total genome of this fungus and are using it to design a population genetic study to determine how long the fungus has been present in Alaska.



Map 12. Spruce bud blight cumulative mapped locations and modeled host tree distribution(s).

Spruce Bud Rust
Chrysomyxa woroninii Tranz.

There were seven observations of spruce bud rust in 2020, six of which came from FHP staff and one from a citizen scientist on iNaturalist. All observations occurred within a similar footprint to those made since 2018, when the disease was noticed and incorporated into exploratory ground surveys. Since the first report in Alaska on white spruce near Fairbanks in 1979, spruce bud rust has been recorded on white, black, Lutz, and Sitka spruce throughout Southcentral and Interior Alaska (Map 13). We have found it as far north as Coldfoot in the southern Brooks Range, as far southwest as Katmai National Park, and east to the Tetlin National Wildlife Refuge near the Canadian Border. The disease results in stunted shoot formation due to infection of buds and female cones. The disease also has life cycle stages on Labrador tea (*Ledum* spp.).



Map 13. Spruce bud rust cumulative mapped locations and modeled host tree distribution(s).

Yellow-Cedar Shoot Blight
Kabatina thujae Schneider & Arx

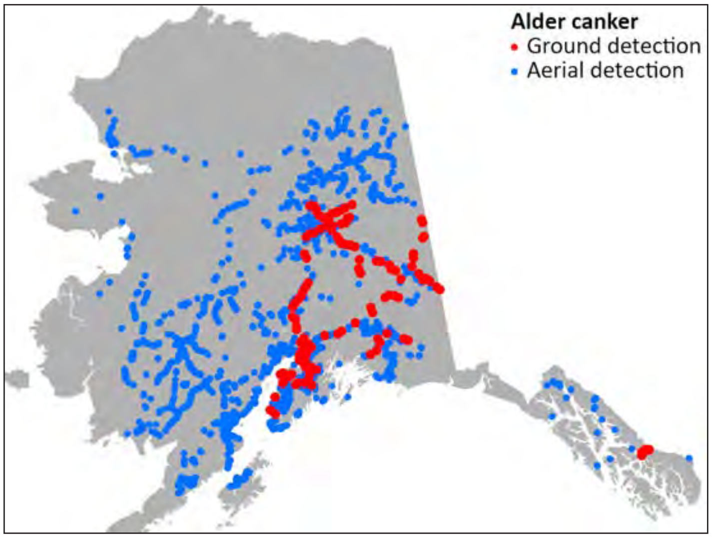
Few ground surveys were conducted in areas with regenerating yellow-cedar in 2020, so the relative incidence and severity of the disease is unknown. Other shoot diseases were more common in 2020 due to wet conditions. Terminal and lateral shoots of yellow-cedar seedlings and saplings typically die from this disease in early spring. Long-term tree structure is not thought to be compromised by leader infections. In 2018, Dr. Jane Stewart from Colorado State University helped us to determine that the same fungus caused yellow-cedar cone infection near Naukati on Prince of Wales Island based on fungal culturing and molecular diagnosis. It is interesting that *Kabatina thujae* is the likely cause of this cone disease, since damage to cones had not been previously documented in Alaska.

Stem and Branch Diseases

Alder Canker
Valsa melanodiscus Otth.
Valsalnicola spp. D. M. Walker & Rossman
And other fungi

In 2020, alder dieback, usually caused by canker-causing fungi (Figure 24), was prevalent on the Kenai Peninsula, around Anchorage, and up the Parks Highway. About 650 acres of dieback were mapped on a northeast-facing slope near Tustumena Lake using high-quality satellite imagery. FHP staff made 49 alder canker observations during ground surveys. Since peak activity in 2011 and 2014, alder canker damage has been steadily decreasing. Significant alder dieback began in 2003 on thin-leaf alder. Since then, we have mapped it on all alder shrub species throughout most of the state (Map 14). *Valsa melanodiscus* was identified as the main causal fungus; however, several other canker fungi also contribute to thin-leaf alder dieback. Dieback on Sitka alder in Southcentral and Siberian alder in the Interior became noticeable around 2014. When alder canker roadside surveys were repeated in 2016 after the inaugural survey in 2006, alder canker was detected at twice as many monitoring sites and showed a marked increase in canker incidence on Sitka and Siberian alder. Alder canker has also been confirmed on Sitka alder in Southeast Alaska, but damage there has not been severe.

Figure 24. An alder canker lesion with bumpy fruiting structures adjacent to smooth healthy tissue. USDA Forest Service photo by Lori Winton.



Map 14. Alder canker cumulative mapped locations. Host tree and shrub distributions are not shown but include alder species in Alaska.

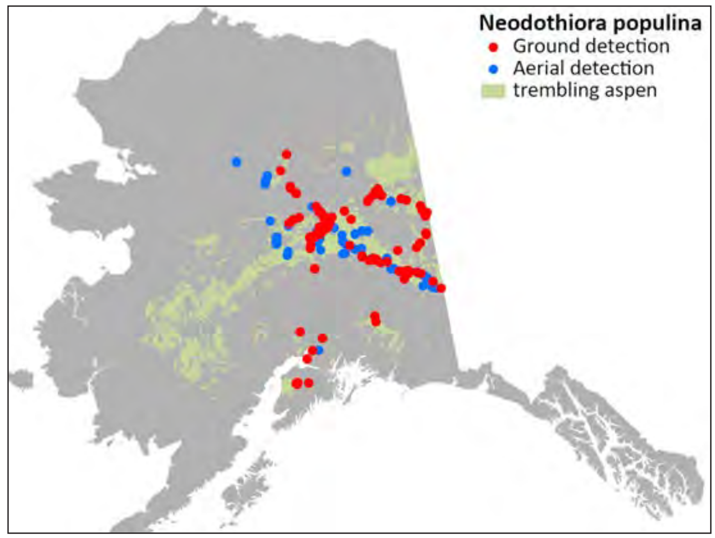
Figure 25. One of about ten trembling aspen trees killed by aspen running canker in a patch of forest near Tok, Alaska. USDA Forest Service photo by Lori Winton.

Aspen Running Canker

Neodothiora populina Crous, G.C. Adams & Winton

Including the eight new records added in 2020, aspen running canker has been mapped throughout the boreal forest of Interior and Southcentral Alaska since it was first discovered in 2015 (Map 15). Most of these locations were found during ground surveys, but we also began mapping this disease in the 2018 aerial detection survey. This is a very aggressive canker disease that can rapidly kill the cambium as it spreads along the tree bole (Figure 25). In smaller understory trees in intermediate-aged to mature stands, the lesions can girdle and kill trees within a single season with no apparent host defenses. Because it is so widespread and often found far from roads and population centers, this disease is most likely caused by a native pathogen that is favored by current conditions of its host and/or environment.

The organism that causes the disease does not form diagnostic fruiting bodies and is difficult to isolate from diseased trees. However, in partnership with Dr. Gerry Adams (University of Nebraska-Lincoln) and Dr. Pedro Crous (Westerdijk Fungal Biodiversity Institute, Netherlands), we have completed pathogenicity tests and determined that the causal agent is a fungus new to science that we have named *Neodothiora populina* Crous, G.C. Adams & Winton (Crous et al. 2020. Persoonia 45: 324-325). We recently completed a study with Dr. Roger Ruess (University of Alaska Fairbanks) which was initiated in 2016 to gain a better understanding of the factors influencing disease distribution and tree responses to infection. A shading experiment to test the hypothesis that vigorous, open-grown saplings have defenses to combat the disease is still in progress. Furthermore, we are exploring whether defenses are constitutive or induced by using transcriptomics to compare gene expression differences between diseased and healthy trees.

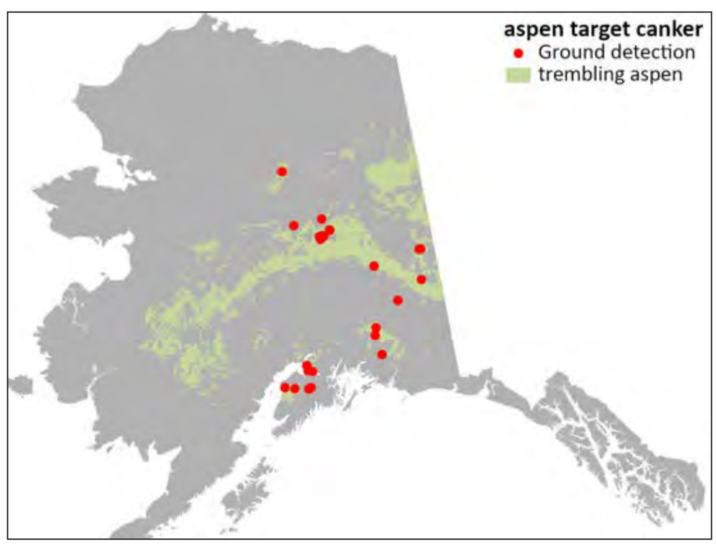


Map 15. Aspen running canker cumulative mapped locations and modeled host tree distribution(s).

Aspen Target Canker

Cytospora notastroma Kepley & F.B. Reeves
And other fungi

We detected aspen target canker at three additional sites in 2020, for a total of 27 records from the Kenai Peninsula, to Chicken near the Canadian border, and north to the White Mountains (Map 16). In contrast to the aspen running canker, it occurs in relatively small, localized pockets. This disease progresses slowly, and individual canker length and breadth is limited by tree response. The cankers are distinctively target-shaped with flaring bark. It takes many years until numerous cankers form on a tree bole and effectively disrupt vascular transport to kill a tree. We have isolated the fungus *Cytospora notastroma* from these cankers. *Cytospora notastroma* is a newly described pathogen that has been found to be a contributor to sudden aspen decline in the Rocky Mountains. More work is needed to determine whether this is the only pathogen involved in aspen target canker in Alaska.

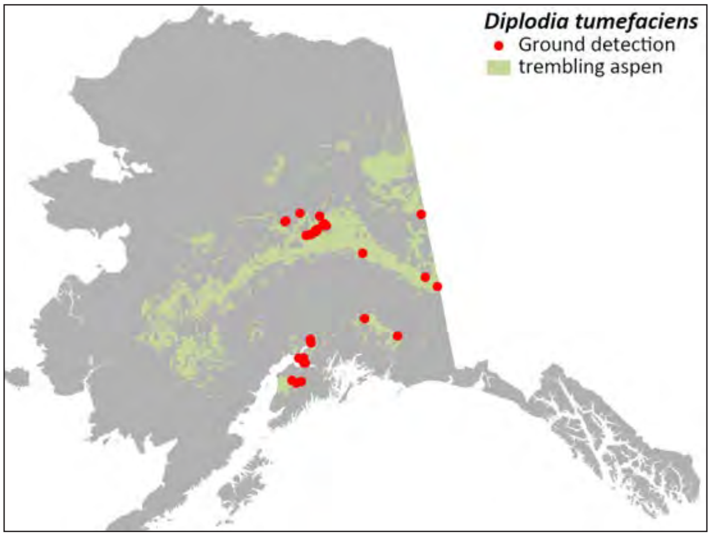


Map 16. Aspen target canker cumulative mapped locations and modeled host tree distribution(s).

Diplodia Gall

Diplodia tumefaciens (Shear) Zalasky

Diplodia gall was recorded at nine sites in 2020 (Figure 26). Over the past few years, we have documented its occurrence at 36 locations. Diplodia galls are well distributed in the Interior from north of Fairbanks to the Canadian border, and at fewer locations in Southcentral, including the northern Kenai Peninsula (Map 17). This disease is reportedly distributed throughout North America on trembling aspen, balsam poplar, and other *Populus* species, but to date we have only recorded it on aspen in Alaska. The patches containing affected trees are generally small and discrete, less than 2 acres in size. When occurring on the trunk, it strongly resembles Chaga, also known as the cinder conk (*Inonotus obliquus*). However, Diplodia gall has only been found on aspen in Alaska, whereas the cinder conk is most common on birch. Galls caused by the fungus can weaken stems and branches, but generally do not kill trees.



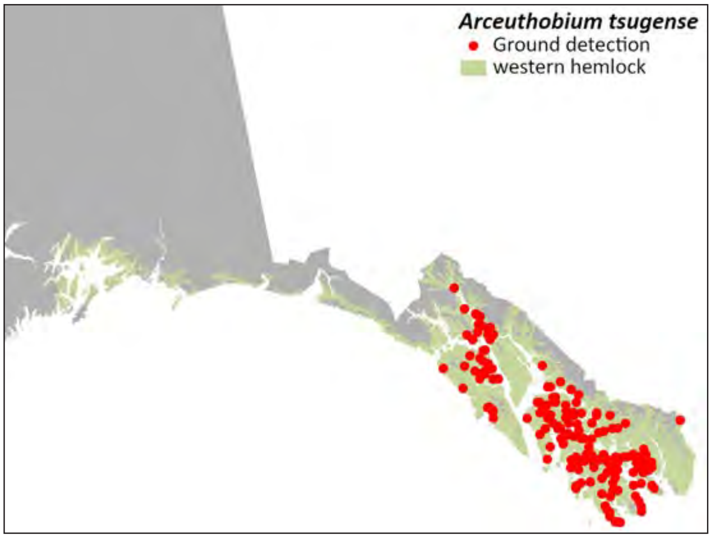
Map 17. Diplodia gall cumulative mapped locations and modeled host tree distribution(s).

Figure 26. A small patch of trembling aspen with Diplodia galls near Fairbanks. USDA Forest Service photo by Lori Winton.

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendahl) G.N. Jones

Hemlock dwarf mistletoe, a parasitic plant, is the leading disease of western hemlock in unmanaged old-growth stands in Southeast Alaska. Hemlock dwarf mistletoe brooms (prolific branching) provide important wildlife habitat and serve as infection courts for decay fungi and tree mortality caused by severe infection creates canopy gaps. The incidence of hemlock dwarf mistletoe does not vary noticeably between years, but four new records were added to our database in 2020 near Juneau and 11 research grade observations were contributed to iNaturalist. Clear-cutting reduces or eliminates dwarf mistletoe in second-growth timber stands for centuries or more. Managers can choose to retain some mistletoe-infected trees for wildlife benefits, since growth loss and mortality only occur at high infection levels. Hemlock dwarf mistletoe is uncommon above 500 feet in elevation and 59°N latitude (Haines, AK) and is absent from Cross Sound to Prince William Sound despite the continued distribution of western hemlock (Map 18).

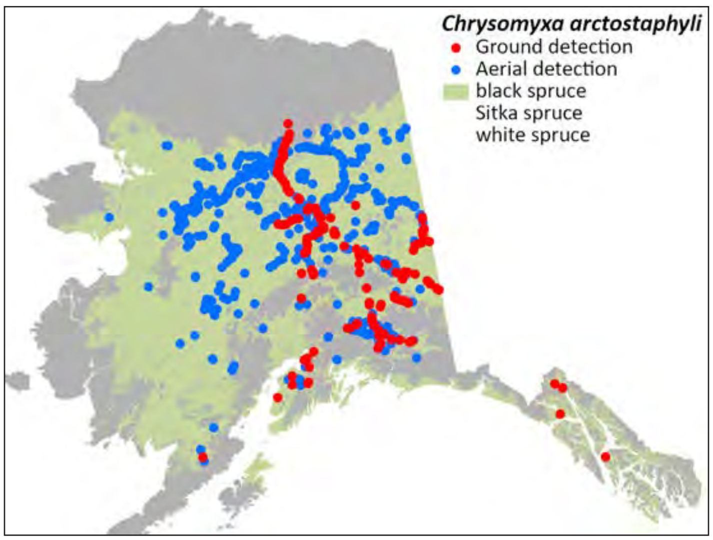


Map 18. Hemlock dwarf mistletoe cumulative mapped locations and modeled host tree distribution(s).

Spruce Broom Rust

Chrysomyxa arctostaphyli Diet.

In 2020, more than 125 spruce broom rust observations were made during ground surveys, all within the previously known disease range (Map 19). Only three research grade observations were reported to iNaturalist. The incidence of perennial brooms (Figure 27) in spruce crowns changes little over time, although aerial detection varies by surveyor, locations flown, and timing of color changes. In 2018, an observation was made on the Seward Peninsula, over 100 miles west of previous detections and west of the proposed range of *Arctostaphylos uva-ursi*, the alternate host plant (based on Hulten, 1968, Flora of Alaska). This part of the state has not since been flown to confirm the record. Broom rust is common and widespread on white and black spruce branches and stems throughout Southcentral and Interior Alaska. It is absent from most of Southeast Alaska aside from Glacier Bay, northern Lynn Canal, and Halleck Harbor on Kuiu Island.



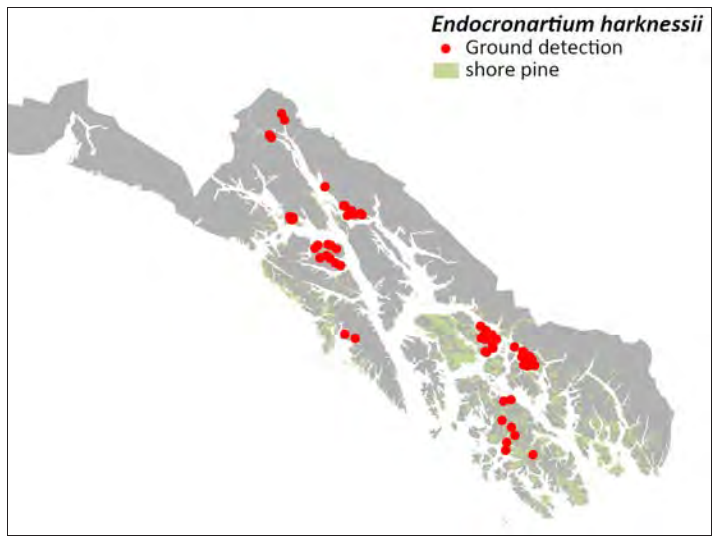
Map 19. Spruce broom rust cumulative mapped locations and modeled host tree distribution(s).

Figure 27. A broom of spruce broom rust on white spruce off the Dalton Highway near the Yukon River. USDA Forest Service photo.

Western Gall Rust

Endocronartium harknessii (J.P. Moore) Y. Hiratsuka (=*Peridermium harknessii*)

Western gall rust (Figure 28) is common throughout the range of shore pine in Southeast Alaska and its incidence does not vary significantly from year to year (Map 20). Secondary insects and fungi invade gall tissue, girdling infected boles and branches. This year's wet conditions likely contributed to a greater incidence of fungal (*Nectria cinnabarina*) infection of galls, leading to increased bole and branch mortality, but this remains to be confirmed. In permanent plots established to evaluate shore pine health in Southeast Alaska, infection was ubiquitous and 85% of live pines were infected. One-third of monitored trees had at least one gall on the main stem (bole galls) that could lead to top kill or whole tree mortality and one-quarter of trees had dead tops associated with bole galls. In 2017, western gall rust was observed sporulating at the edge of a large, diamond-shaped canker on a shore pine tree bole in Gustavus, suggesting that it likely causes this common type of bole canker (i.e., hip canker). Another stem rust, stalactiform blister rust caused by *Cronartium coleosporioides*, was recently detected on shore pine near Haines (molecularly confirmed) and Gustavus (suspected).



Map 20. Western gall rust cumulative mapped locations and modeled host tree distribution(s).

Figure 28. Western gall rust sporulating on shore pine. USDA Forest Service photo by Robin Mulvey.

Stem Decays

Brown Crumbly Rot

Fomitopsis pinicola (Swartz ex Fr.) Karst

Over 20 observations of *Fomitopsis pinicola* (red belt conk) were recorded in 2020 by FHP staff, with an additional 30 research grade observations from citizen scientists reported in iNaturalist. Many of our observations were associated with the substantial spruce beetle activity in the Matanuska-Susitna Valley on white spruce. In this area, many of the spruce beetle-killed trees snapped off in the lower bole. Almost all of them had red belt conks and brown, crumbly, decayed wood with mycelial mats in the cracks. It is assumed that the trees had been infected long before they snapped because of the extensive advanced decay. Two popular Southcentral Alaska state campgrounds were closed in 2019 (Byers Lake Campground and South Rolly Lake Campground in the Nancy Lakes State Recreation Area) because of hazard trees created by spruce mortality, but reopened in 2020. *Fomitopsis pinicola* is presumed to occur throughout the range of its hosts and has been recorded on all spruce and hemlock species in Alaska (Map 21).

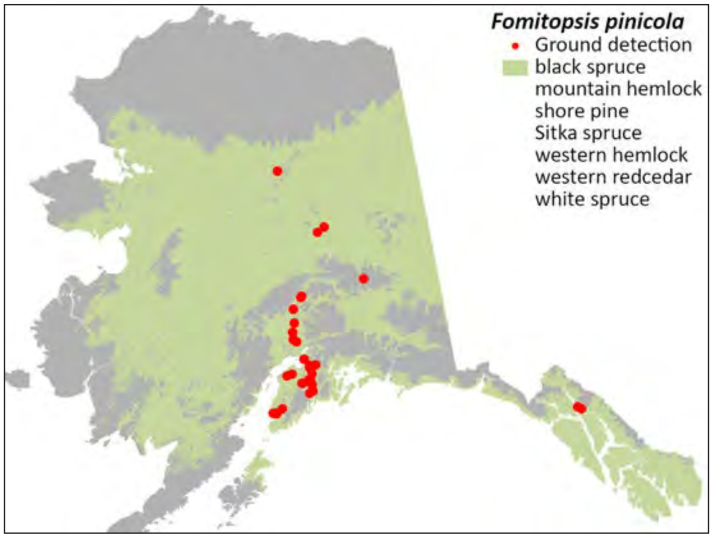
Two recent publications indicate that *Fomitopsis pinicola* is not a single species, but rather a cryptic species complex (Haight et al. 2016, *Mycologia*, 108(5), pp. 925–938; Haight et al. 2019, *Mycologia*, 111 (2), pp. 339-357). Phylogenetic analyses show that two species are likely present in Alaska: *F. ochracea* and *F. mounceae*. They co-occur in coastal Alaska, but only *F. mounceae* is present in Interior and Western Alaska. The red band that gives the conk its common name, red belt, is thought to be more characteristic of *F. mounceae*. Consequently, iNaturalist discontinued *Fomitopsis pinicola* as an accepted taxon, which has created some obstacles in interpreting citizen scientist reports that base identification on location or presence of the red belt. We will continue to call this fungus *F. pinicola* or *F. pinicola* sp. complex until there is broader adoption of the newly suggested scientific names.

DISEASES

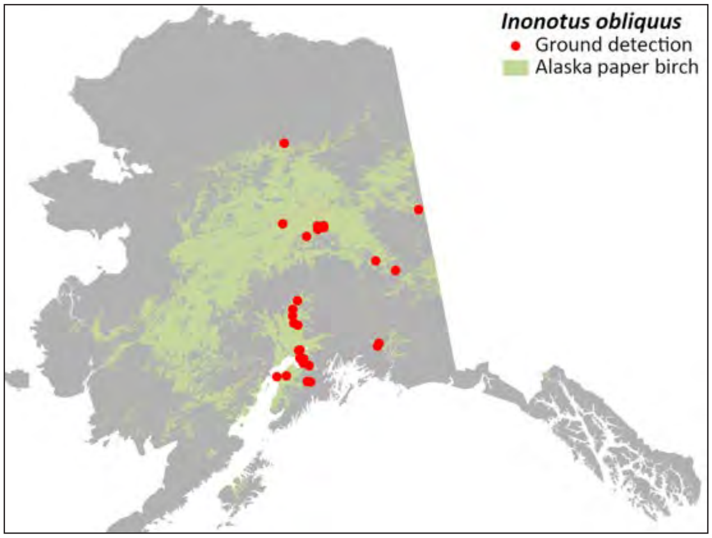
Canker-Rot of Birch

Inonotus obliquus (Ach. ex Pers.) Pilat

Eleven new locations of *Inonotus obliquus* were recorded by FHP staff in 2020, with five additional research grade observations recorded by citizen scientists in iNaturalist. Our forest health protection team has documented it in 44 locations from the Kenai Peninsula, north to the Brooks Range, and east to Eagle (Map 22). Also known as Chaga, it is easy to identify on birch trees; a superficially similar symptom is the Diplodia gall on aspen. Unlike most stem decays, *I. obliquus* is a primary colonizer that kills and decays sapwood and the inner bark, killing it and the vascular cambium.



Map 21. Brown crumbly rot disease cumulative mapped locations and modeled host tree distribution(s).

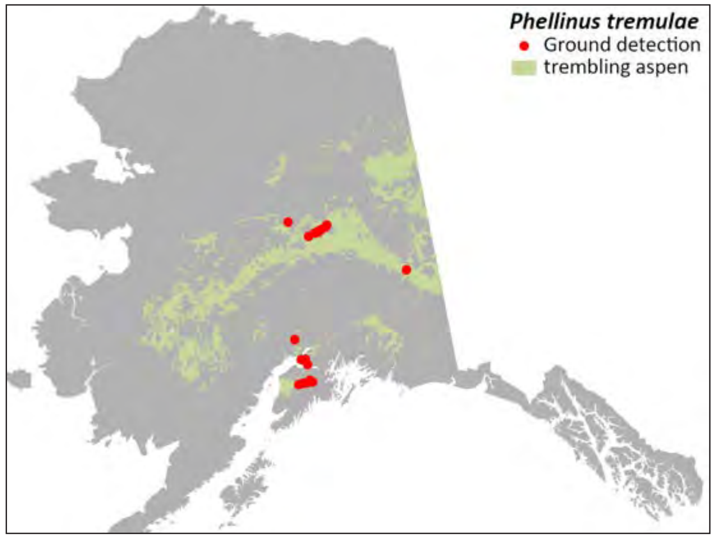


Map 22. Canker-rot of birch disease cumulative mapped locations and modeled host tree distribution(s).

Trunk Rot of Aspen

Phellinus tremulae (Bord.) Bond et Boriss

Phellinus tremulae only occurs on aspen, although the conk appears identical to *P. igniarius*. In 2020, we added five new records for a total of 30 mapped locations in Alaska (Map 23), with two additional research grade observations reported in iNaturalist. *Phellinus tremulae* is considered the most important decay pathogen of aspen species in the Northern Hemisphere.



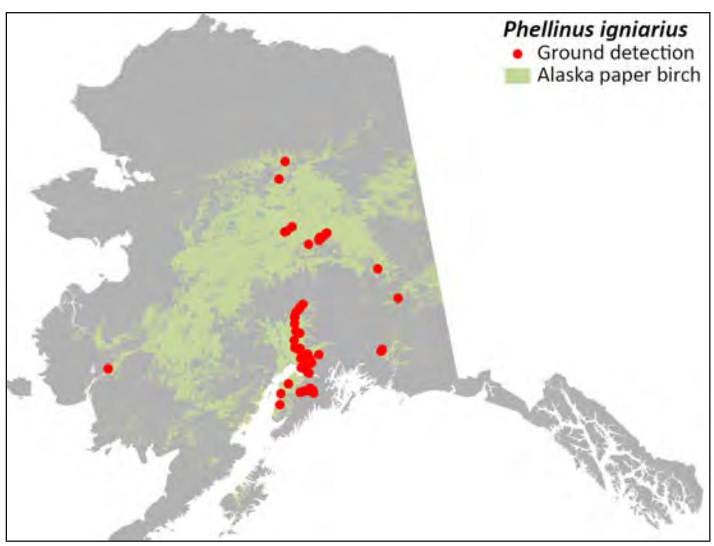
Map 23. Trunk rot of aspen cumulative mapped locations and modeled host tree distribution(s).

Trunk Rot of Birch

Phellinus igniarius (L.:Fr.) Quel.

We recorded 24 new locations of trunk rot on birch (caused by *P. igniarius*), all south of the Alaska Range (Figure 29), with six additional research grade observations made in iNaturalist. This disease is extremely widespread and common in Alaska on both live and dead birch trees (Map 24). Although reported on many hardwood species elsewhere, in Alaska we have only observed it on birch, alder, and willow species. This fungus is known as an important white rot of hardwoods in the cooler regions of northern temperate forests.

Figure 29. A *Phellinus igniarius* conk on birch in Denali State Park. USDA Forest Service photo.



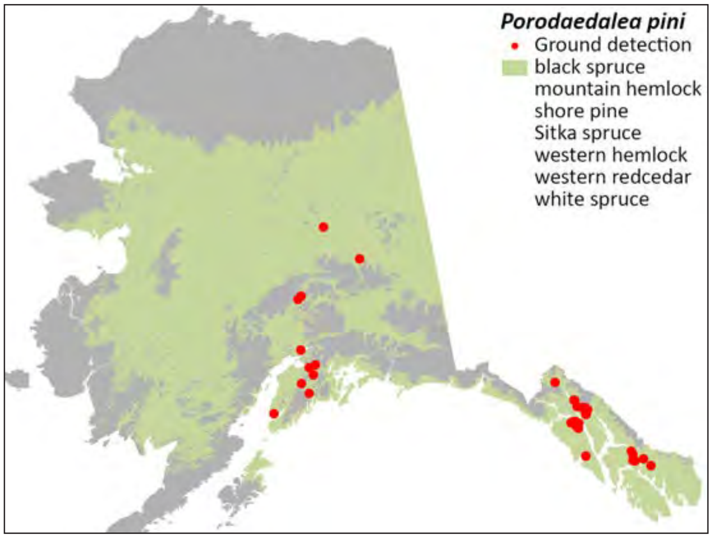
Map 24. Trunk rot of birch cumulative mapped locations and modeled host tree distribution(s).

Red Ring Rot

Porodaedalea pini (Brot.) Murrill
(=*Phellinus pini*)

Porodaedalea pini was recorded on white, black, and Sitka spruce at three locations in Southcentral and Interior Alaska in 2020. Near Juneau, eight occurrences were found on Sitka spruce and western and mountain hemlocks (Map 25). Seven research grade observations were recorded in iNaturalist. An impressive patch of more than 30 affected mountain hemlocks was found on the slope of Mt. McGinnis above the Mendenhall Glacier in Juneau. Fruiting bodies (Figure 30) often occur near branch stubs on live trees and are an indicator of heart rot. Extensive internal decay is often indicated by multiple fruiting bodies along the length of the bole. Although primarily considered a heart rot, *P. pini* can progress into sapwood and kill trees.

Figure 30. *Porodaedalea pini* conks are ubiquitous on mountain hemlock on the slopes of Mt. McGinnis near Juneau. USDA Forest Service photo by Robin Mulvey.

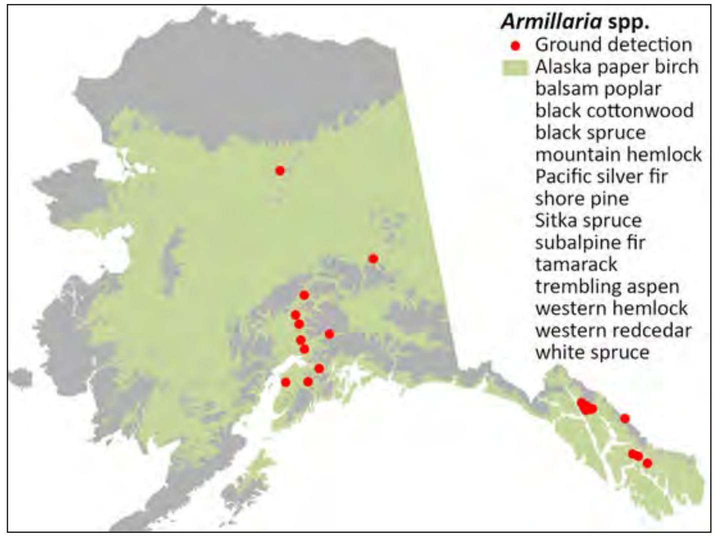


Map 25. Red ring rot disease cumulative mapped locations and modeled host tree distribution(s).

Root and Butt Diseases

Armillaria Root Disease
Armillaria spp.

Armillaria root disease has been mapped on paper birch and white spruce in several locations in Interior and Southcentral Alaska and on many hosts in Southeast Alaska (Map 26). In Southeast Alaska, *Armillaria* species are thought to hasten the death of stressed trees rather than directly cause mortality or to decompose wood after tree death (Figure 31). Drs. John Hanna and Ned Klopfenstein (Rocky Mountain Research Station) led a west-wide project on the identity and distribution of *Armillaria* species, which detected *A. sinapina* and *A. nabsnona* in Southeast Alaska. More recently, they used climate envelope modeling to evaluate whether future climate scenarios favor our native *Armillaria* species, as well as assessing climate suitability for more aggressive *Armillaria* species presently found in the Pacific Northwest but not Alaska. Their findings suggest that relative climate suitability (i.e., land area with climate associated with a higher probability of disease presence) becomes greater for native species and non-native *A. solidipes* (the primary pathogen in the PNW) and *A. cepistipes* under future climate scenarios. They posit that based on these predictions, both species present potential invasive threats to Southeast Alaska under conditions of predicted climate change. These results were based on 32 *A. sinapina* isolates collected by our group from 12 locations in Southeast Alaska from 2016 to 2018. A single isolate of *A. nabsnona* was identified from a dying yellow-cedar crop tree on Prince of Wales Island, but this was insufficient for bioclimatic modeling. Collections from hardwood and conifer hosts from the Kenai Peninsula to the Arctic Circle in 2007 were all identified as *A. sinapina*.

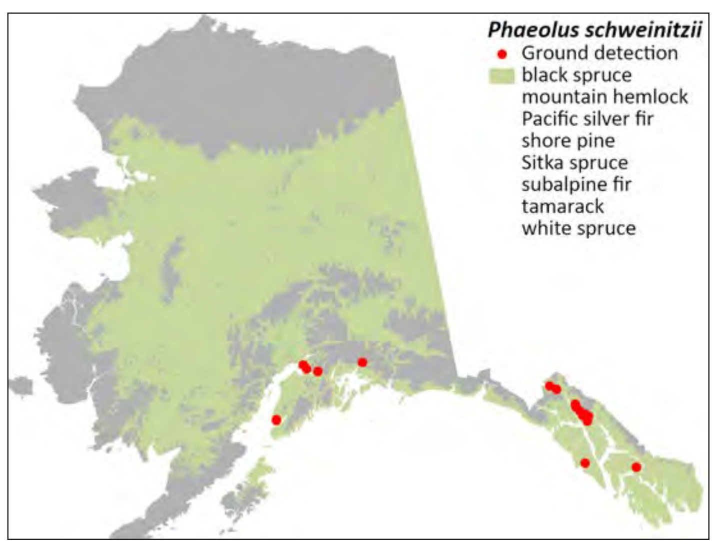


Map 26. Armillaria root disease cumulative mapped locations and modeled host tree distribution(s).

Figure 31. Abundant Armillaria mushrooms on a beaver-cut red alder near Juneau. USDA Forest Service photo by Robin Mulvey.

Brown Cubical Butt Rot
Phaeolus schweinitzii (Fr.:Fr.) Pat.

In 2020, *Phaeolus schweinitzii* was recorded at two locations in Southcentral Alaska on Sitka and white spruce, as well as two adjacent locations on Sitka spruce near Juneau. Ten research grade observations were contributed through iNaturalist. This fungus is particularly common on Sitka spruce in Southeast Alaska (Map 27). The fruiting bodies are most noticeable in fall, emerging from decayed wood of broken tree boles or the soil around trees, connected to tree roots below ground. Damage can be most severe in areas with compacted or disturbed soils. For this reason, this fungus increases hazard tree issues at recreation sites, where infrastructure development or aggressive public use may inadvertently compromise tree roots and encourage infection. The brown cubical rot symptom of *P. schweinitzii* may easily be mistaken for that caused by the much more common *Fomitopsis pinicola*.

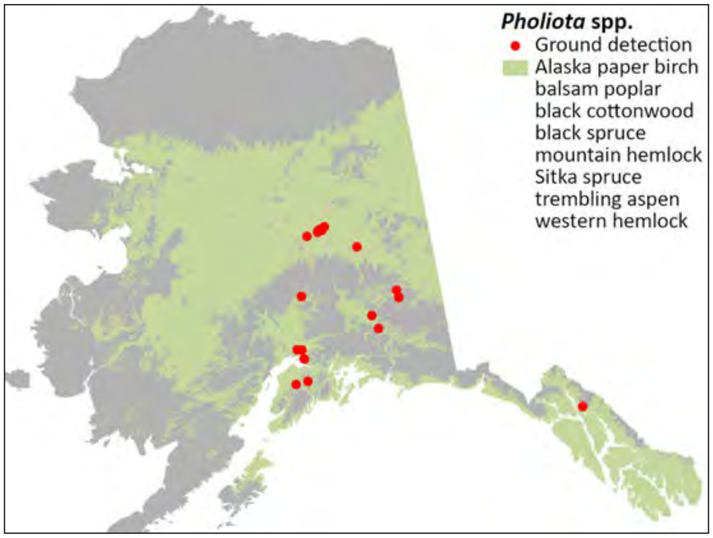


Map 27. Brown cubical butt rot disease cumulative mapped locations and modeled host tree distribution(s).

Figure 32. Pholiota mushrooms growing from a crack in a birch tree in Denali State Park. USDA Forest Service photo.

Pholiota Butt Rot
Pholiota spp.

In 2020, one record of *Pholiota* was documented on birch (Figure 32) in Denali State Park. To date, many *Pholiota* occurrences have been mapped on aspen, birch, black spruce, and willow in Southcentral and Interior Alaska (Map 28) but most have not been identified to species. Many *Pholiota* citizen science observations were made in 2020 in iNaturalist. At least ten observations appeared to correctly identify the genus; however, even some of the observations labeled as research grade were likely erroneous in that they were identified to species when true identification can be challenging and/or require molecular tools. Unfortunately, iNaturalist records seldom include host tree information, which can aid in identification. *Pholiota* mushrooms are most common at the base of trembling aspen, but usually these trees have no symptoms until they uproot or snap near the root collar. Last year, mushrooms found on a live Sitka spruce and a western hemlock tree near Juneau were molecularly confirmed as *Pholiota* (99% sequence match to *Pholiota aurivella*). *Pholiota* is less frequently encountered in Southeast Alaska than other parts of the state.



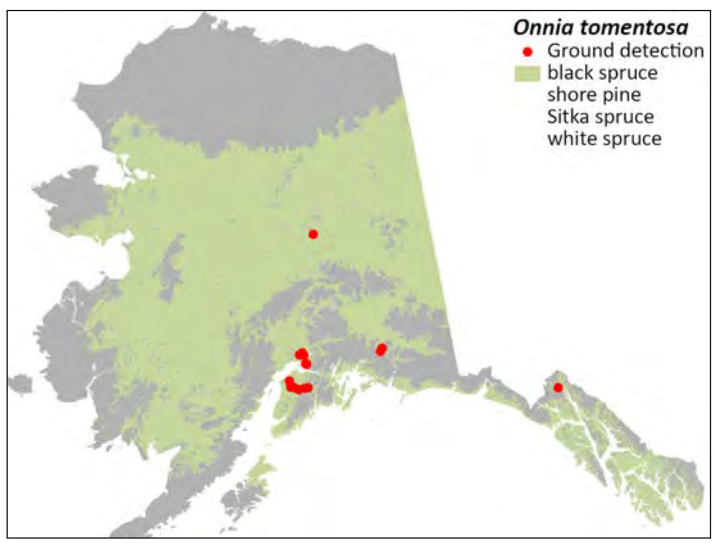
Map 28. Pholiota butt rot disease cumulative mapped locations and modeled host tree distribution(s).

Figure 33. A fruiting body of *Onnia tomentosa* growing from the roots of a black spruce near Cooper Landing. USDA Forest Service photo.

Tomentosus Root Rot

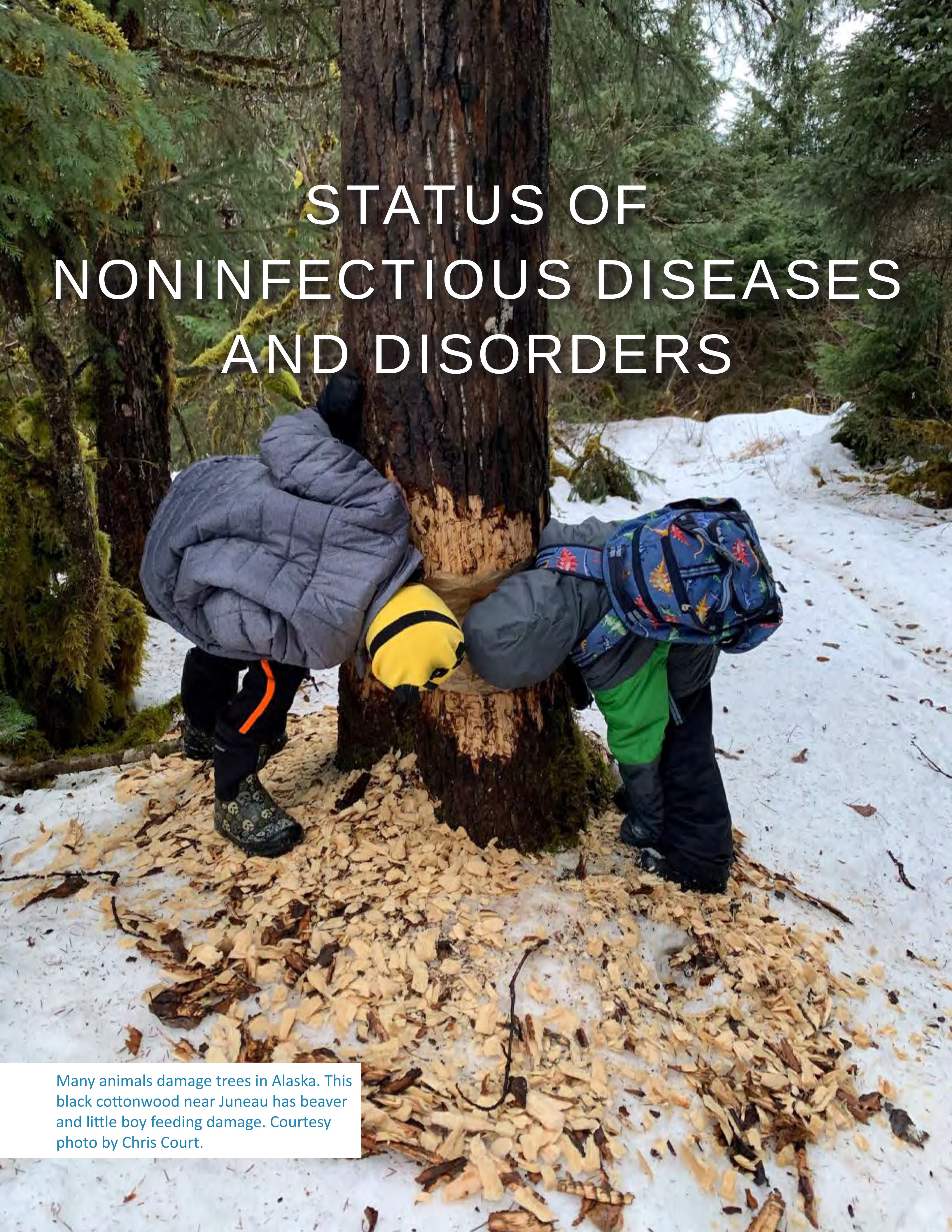
Onnia tomentosa (Fr.) P. Karst. (=*Inonotus tomentosus*)

We recorded five occurrences of *O. tomentosa* in 2020, all in Southcentral. A further eight research grade observations were made in 2020 between Anchorage and Cooper Landing in iNaturalist. The pathogen is presumed to be widespread throughout spruce stands of Southcentral and Interior Alaska. However, because the fruiting structures are ephemeral (Figure 33) and it is difficult to confidently identify without them, it has only been confirmed and mapped in 29 locations (Map 29). Post-harvest stump surveys in Interior Alaska have shown very high incidence of decay and stain symptoms consistent with Tomentosus; however, fruiting bodies of the fungus are seldom found at the time of survey. The lack of above-ground diagnostic features are obstacles to detection and inclusion in comprehensive surveys. In Southeast Alaska, this pathogen has been reported on Sitka spruce and shore pine near Skagway, Haines, and Hoonah.



Map 29. Tomentosus root rot cumulative mapped locations and modeled host tree distribution(s).

STATUS OF NONINFECTIOUS DISEASES AND DISORDERS



Many animals damage trees in Alaska. This black cottonwood near Juneau has beaver and little boy feeding damage. Courtesy photo by Chris Court.

2020 NONINFECTIOUS DISEASES & DISORDERS UPDATES

Abiotic Damage

Windthrow, flooding, drought, winter injury, and wildfires are common forms of abiotic damage in Alaska that affect forest health and structure to varying degrees. Wildfire is not mapped during our forest health surveys but causes extensive tree mortality in Alaskan boreal forests and may be especially severe after bark beetle outbreaks or in times of drought. The Alaska Interagency Coordination Center (https://fire.ak.blm.gov/) reported that 348 fires burned across 181,249 acres in 2020, only 7% of the area burned in 2019. Yellow-cedar decline is one of the best examples of climate-induced forest decline in the world and the decline mechanism is well-understood.

Drought

Scattered individual dying white and Lutz spruce were observed along the north side of Turnagain Arm in 2020 as well as on the south side of Turnagain Arm in the vicinity of Gull Rock (150 acres). Scattered dead spruce, many of which appear to be on rocky outcrops or other sites with shallow soils, are believed to have died due to drought conditions that occurred in 2019, perhaps compounded by secondary damage agents. Spruce beetle attacks were noted on some of the affected trees on the north side of Turnagain Arm, though not with a density of attacks on stems likely to have caused mortality. In addition to the scattered dying spruce, some patches of presumed drought-related mortality affecting a mix of tree and shrub species were also observed in this area. The US Drought Monitor noted these general areas as having lengthy periods of moderate or higher drought conditions in 2019, beginning in July and continuing well into the fall (https://droughtmonitor.unl.edu/Maps/MapArchive.aspx).

Mast Seeding of Aspen

Increased aspen seed production was observed in late May and early June in Southcentral Alaska. Like cottonwoods, aspen female catkins produce cottony seeds, though usually in less conspicuous quantities. On the central Kenai Peninsula near Sterling Highway they produced almost cottonwood-levels of seeds (Figure 34). Similar observations were made in parts of Anchorage and Eagle River. Thin crowns were observed in the trees on the Kenai, while premature leaf drop was observed near Eagle River and Anchorage, with several reports from Anchorage residents. The additional energy that went into fruit production may have impacted leaf growth and maintenance in these areas. It is not known what triggered mast seeding.

Figure 34. Aspen seed production observed in early June on the Kenai Peninsula. USDA Forest Service photo.

Figure 35. A dead western redcedar top exhibiting brown foliage on Prince of Wales Island. USDA Forest Service photo by Molly Simonson.

Western Redcedar Topkill

The cause of western redcedar topkill (Figure 35) on Prince of Wales Island is under investigation. This problem usually affects trees 5 to 12 inches in diameter. It is most concentrated along roads and has been detected in managed stands and in old-growth. Associated tree species are unaffected. Bole wounds with missing bark were common in damaged parts of the crown but were not found on all affected trees. Further assessment could help to define site factors associated with topkill and mortality. Drought is thought to be the most important abiotic cause, which may predispose trees to biotic stressors, such as animals that feed on inner bark, canker fungi, or bark beetles. Severe drought occurred on Prince of Wales Island in 2018 and 2019, followed by excessive rainfall in 2020. Interestingly, elevated mortality was first noticed in 2017, prior to excessively dry conditions. Retrospective climate analyses could help to identify climate trends in 2016 linked to the uptick in damage noticed in 2017.

Of 260 damage observations made in 2019, half were made from the air and half from the ground, almost always reflecting damage to one or a few trees. In 2020, we used high-resolution satellite imagery to identify 17 points of western redcedar topkill or mortality, however we were unable to ground check the mapped damage. We aim to assess these areas on the ground as soon as possible. This damage is more difficult to confidently detect from imagery compared to aerial surveys. Regardless of whether this damage is detected via aerial surveys or imagery scanning, it must be ground confirmed, since western redcedar topkill or dieback may look like young-growth yellow-cedar decline when yellow-cedar is killed rapidly by secondary bark beetles.

There is now a multi-regional and -agency effort to understand the abiotic and biotic causes of the notable increase of western redcedar mortality through the Pacific Northwest. The virtual 2020/21 Western Redcedar Summit focused on emerging western redcedar dieback research in both urban and wildland environments. Presenters and participants represented multiple government agencies, municipalities, and universities from Oregon, Washington, Alaska, and British Columbia. A collaborative survey form (Figure 36) has been created by the Oregon Department of Forestry in the Survey123 application to facilitate widespread data collection by forest health staff from universities and state and federal agencies.

Figure 36. A screenshot of the collaborative survey to track western redcedar topkill and mortality across Oregon, Washington, Alaska, and British Columbia.

Windthrow

Only 14 acres of wind damage were mapped in 2020. Two patches of windthrow occurred near Little Baht Harbor on northern Zarembo Island, while three patches were mapped on Perl Island off the southern tip of the Kenai Peninsula using high-resolution satellite imagery. Extreme winds and heavy precipitation of several consecutive extratropical storms hit Southeast Alaska in early December, which caused abundant tree failure of individual trees and small clusters of trees. Aerial surveys or satellite imagery may detect larger patches of forest affected by these gales. This extended storm event caused the December 2020 mudslide in Haines that resulted in two fatalities and destroyed several homes. Stem decay, root disease, high height-to-diameter ratios, and shallow, saturated soils are all factors that increase tree failure potential in high winds.

Animal Damage

Throughout the state, several animal species cause damage to forest trees. Porcupines and beavers kill trees by girdling tree boles whereas beavers also cause flooding which can lead to tree mortality. In Southeast Alaska, brown bears selectively feed on the inner-bark of yellow-cedar trees in the spring; approximately half of the yellow-cedar trees on islands with high brown bear populations have feeding scars.

Porcupine
Erethizon dorsatum L.

In 2020, only 120 acres of porcupine damage were reported, all in young, managed stands. About half were detected using high-resolution satellite imagery on the southwestern Chilkat Peninsula and the remainder were detected on western Wrangell Island through ground surveys. In recent years, several thousand acres of porcupine damage have been reported annually. The dip in acreage in 2020 is likely an artifact of changes to survey methods this year rather than reduced activity. Porcupines (Figure 37) can be major pests in managed young-growth stands where they girdle Sitka spruce and western hemlock managed for timber. They often wound the largest and fastest growing trees. Historic porcupine migration patterns from mainland river valleys to offshore islands has influenced their current distribution in the Alexander Archipelago. Porcupines are absent from Admiralty, Baranof, Chichagof, Kupreanof, Zarembo, and Prince of Wales Islands (and others) near to the Gulf of Alaska but are abundant closer to, or on, the mainland.

Snowshoe Hare
Lepus americanus Erxleben

Pronounced winter browse damage by snowshoe hare was recorded in the Interior in 2018 and 2019, especially along the Dalton Highway between Coldfoot and Atigun Pass. This area was not surveyed in 2020. In areas of the Interior that were surveyed this year, damage was not noticeable, which is consistent with decreased hare populations in the region.

Forest Declines

Yellow-Cedar Decline

Yellow-cedar decline, caused by root-freezing injury in the absence of insulating snowpack, is the most significant threat to yellow-cedar populations in Alaska (Figure 38, page 39). We are continuing to monitor yellow-cedar decline in old-growth forests and, more recently, in previously harvested stands that continue to be managed for timber (young-growth).

Figure 37. Porucpine damage. USDA Forest Service photo by Robin Mulvey.

Active Yellow-Cedar Decline Detection in 2020
Surveys in 2020 focused entirely on available high-resolution satellite imagery. Within the range of yellow-cedar and known decline in Southeast Alaska, available imagery covered a large portion of Prince of Wales Island and the southern tip of Etolin Island (Map 30, page 41). More than 10,000 acres of active decline were detected, which is higher than the acreage typically mapped in that area by aerial survey. Prince of Wales was intensely aerially surveyed in 2019 with 7,500 acres of decline recorded. Also, a special aerial survey of Prince of Wales Island was conducted in October 2015, with the goal of comprehensively mapping elevated recent decline and identifying areas with large diameter snags for salvage harvest consideration. During this survey, we mapped over 26,000 acres of decline on the island, with a significant portion of it detected in areas that had never (or rarely) been surveyed.

Imagery-based remote-sensing techniques enable surveyors to map active decline in greater detail and with better spatial accuracy on the landscape than is possible while flying at 100 mph in an airplane. In 2004, yellow-cedar decline detected in aerial imagery was compared to damage mapped by aerial survey around Peril Strait, followed by evaluation of decline on Mt. Edgecumbe near Sitka in 2009. We found that aerial surveys under-mapped decline where tree mortality was scattered and over-mapped the total spatial extent of decline, compared to aerial photo interpretation. Higher mapped acreage through aerial survey resulted from a lumping-versus-splitting approach (large polygons around declining forest) and errors of commission that accumulate as the same patch of declining forest is mapped over time, slightly askew on the landscape. The total area of aerially mapped polygons is counted toward the cumulative decline

Figure 38. A mix of dead and dying yellow-cedar in a forest affected by yellow-cedar decline along Slocum Arm of western Chichagof Island. USDA Forest Service photo by Robin Mulvey.

acreage. Crown discoloration symptoms may be present for a decade or more as trees gradually die, increasing the likelihood of repeat mapping of affected forests. Photo-interpretation mapping with aerial imagery resulted in a far greater number of damage polygons, but also a smaller total acreage, indicating the finer scale detection of this method. Each method of mapping yellow-cedar decline has advantages and the differences in decline estimates correspond to differences in survey scale. The use of high-resolution satellite imagery to map new or cumulative decline may help us to develop the most fine-scale and comprehensive decline layer. The effort would be time-intensive, but imagery quality and availability has increased substantially over the last decade.

The current northern margin of decline on the outer coast of Chichagof and Yakobi Islands has not been carefully surveyed for the last several years. An effort will be made to map these areas soon to evaluate potential change in the northern extent of decline. A 2011-12 study conducted in partnership with Lauren Oakes documented northward expansion of decline in this area. A small patch of old yellow-cedar mortality was found alongside La Palouse Glacier in Glacier Bay National Park, which may have been caused by localized, uncommon freezing events in this area of otherwise healthy yellow-cedar populations. Dr. Benjamin Gaglioti (Lamont-Doherty Earth Observatory of Columbia University) used a dendrochronology approach to assess yellow-cedar snags at the site, including 30 now-exhumed snags that were already dead when they were buried by aggrading outwash and advancing glacial ice ca. 1862 and 31 snags in the adjacent old-growth forest. The snags were defined as Class IV and V according to the yellow-cedar snag rating system (Figure 39, page 40). All but one snag had been standing for greater than 100 years since tree death. Healthy yellow-cedar persist in the adjacent forest.

In total, more than 600,000 acres of yellow-cedar decline have been mapped across Southeast Alaska (Map 30, page 41; Table 4, page 42). At lower latitudes, active decline occurs at relatively higher elevations compared to declining forests farther north, indicating the influence of lower snow levels. Over the last several years we have used GIS tools to improve this cumulative estimate by restricting decline to upland forest and forested wetlands (two land cover classes in the NLCDmodified dataset, Frances Biles, Forest Service, PNW Research Station). The use of this forest mask reduces the total cumulative acreage of yellow-cedar decline by more than 50,000 acres compared to the unfiltered total.

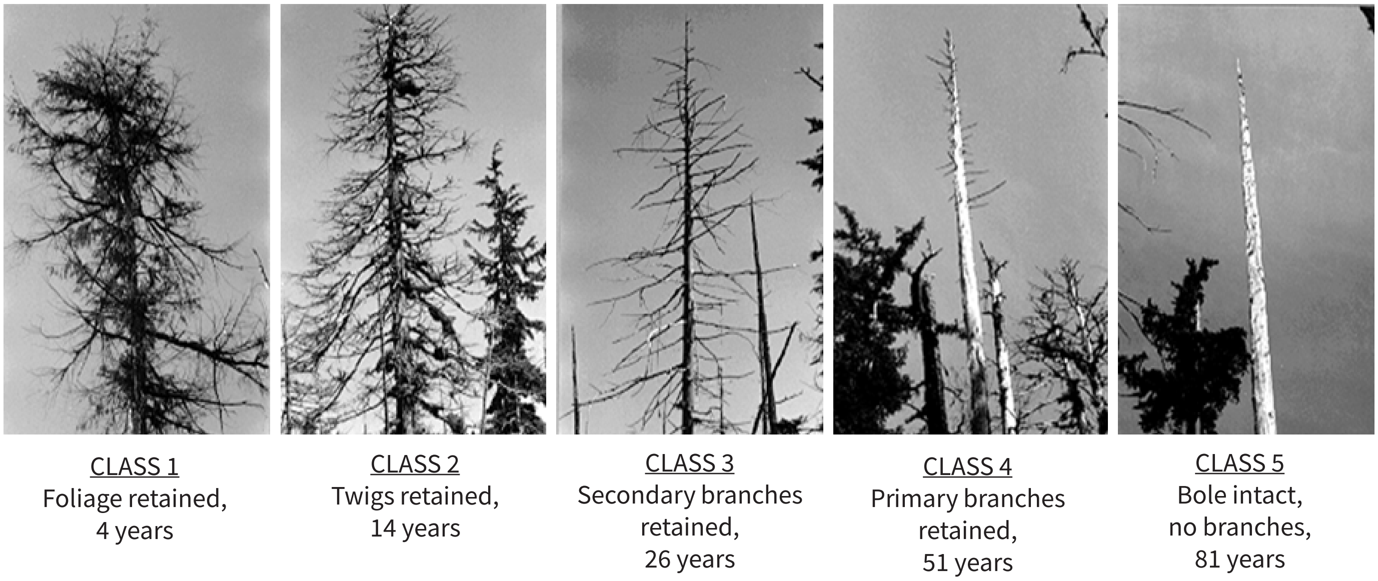


Figure 39. Appearance, characteristics, and mean time-since-death for the five dead tree (snag) classes of yellow-cedar (Hennon et al. 1990). Graphic from Oakes et al. 2014, adapted from Hennon 1990 (used with permission).

Young-Growth Yellow-Cedar Decline

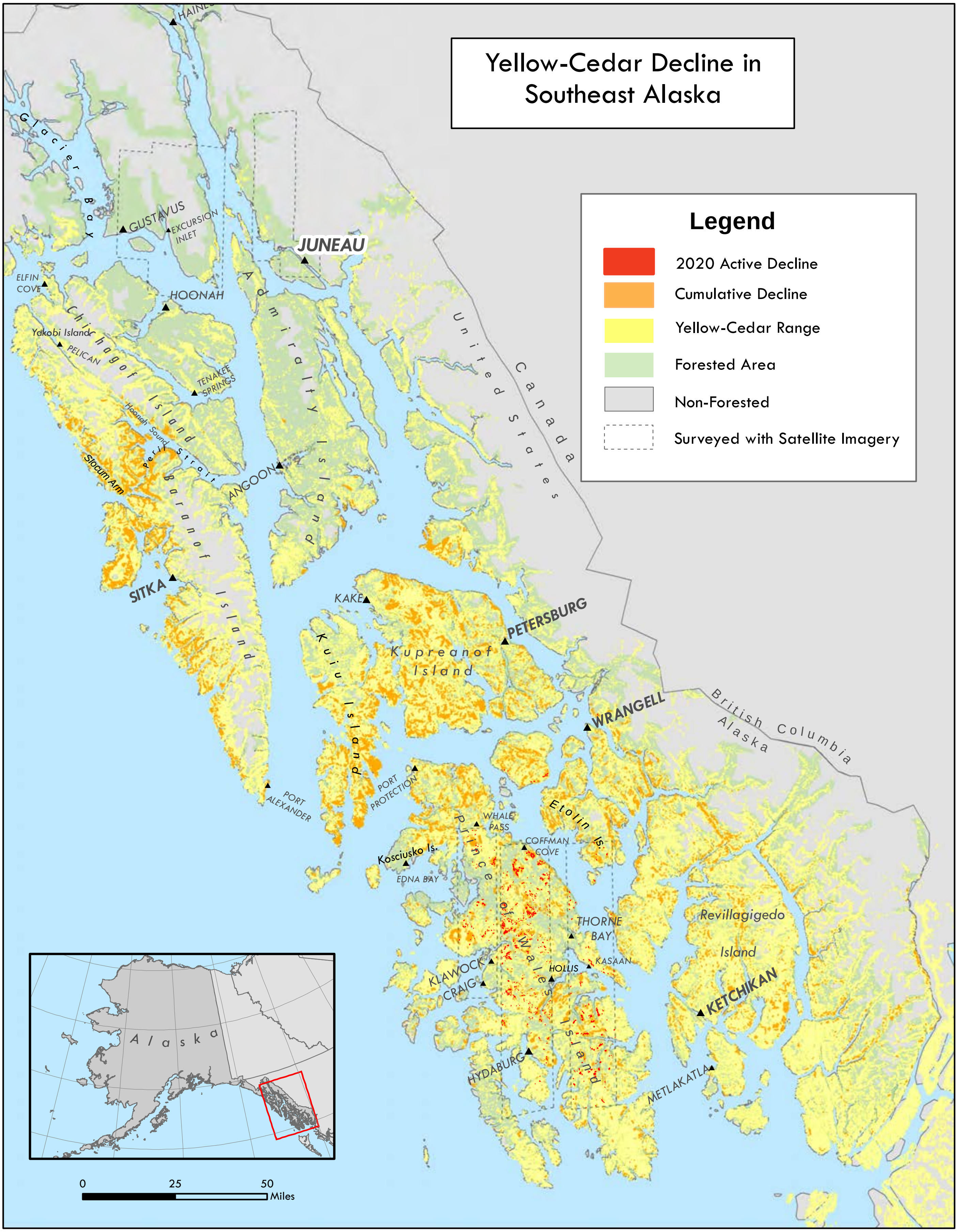
Young-growth yellow-cedar decline is an emerging issue, particularly where soils are wet or shallow. The problem was first observed in young-growth forests on Zarembo Island in 2012; previously, decline was thought to be a problem restricted to old-growth forests. We created a database of managed stands on the Tongass National Forest known to contain yellow-cedar (now 338 stands). Low-altitude aerial imagery and aerial detection surveys were used alongside the database to identify stands with discolored tree crowns and suspected decline, which are then 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. Affected stands are typically 27- to 45-years-old, were thinned between 2004 and 2012, and occur on south to southwest aspects. Decline has now been detected in 18 percent of stands in our database that fall within the highest-risk age bracket (27-45 years old). Half of the stands in our database are in this age range and one-third are younger.

In 2018, we installed 41 permanent plots in the five most severely affected stands to assess damage severity. In these plots, eight times more yellow-cedar crop trees were dead than all other tree species combined, though only two percent of yellow-cedars were dead overall. In individual plots, up to 26 percent of yellow-cedars were dead, and up to eight percent of yellow-cedars were dead in evaluated stands. Overall, one-third of yellow-cedar trees had crown discoloration symptoms. The condition of symptomatic trees is expected to worsen based on the progressive nature of individual yellow-cedar death in declining old-growth forests. The highest rates of mortality occurred where secondary bark beetles (*Phloeosinus* spp.) were attacking the stressed trees, causing more rapid tree death than occurs with freezing injury alone. We plan to revisit these stands to reassess mortality rates by 2022.

One hypothesis is that opening tree crowns through thinning may trigger decline onset by exposing the soil around trees to greater temperature fluctuation. If true, tighter spacing around yellow-cedar trees or foregoing thinning treatment in wet, lower productivity parts of stands could be beneficial. Improving our ability to predict where young-growth decline is likely to occur could allow for the prioritization of other conifers during thinning in the areas expected to be most vulnerable to decline, or the implementation of alternative thinning regimes.

Endangered Species Act Decision

In October 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. The petition to list yellow-cedar was received in June 2014. The initial finding was that a review of the science and status of yellow-cedar was warranted. The Yellow-Cedar Species Status Assessment was completed in December 2018.



Map 30. Current (2020) yellow-cedar decline mapped in Southeast Alaska using high-resolution satellite imagery and cumulative yellow-cedar decline mapped by aerial survey since the 1980s.

Table 4. Cumulative acreage affected by yellow-cedar decline as of 2020 in Southeast Alaska by ownership. Estimates were limited to affected areas occurring within upland forest and forested wetlands using two of the land cover classes in the NLCD-modified dataset (Frances Biles, Forest Service, PNW Research Station).

Ownership	*Cumulative Acres*
National Forest	**621,850**
Admiralty NM	**5,300**
Admiralty Is.	5,300
Craig RD	**42,849**
Dall Is. & Long Is.	1,590
Prince of Wales Is.	41,260
Hoonah RD	**782**
Chichagof Is.	782
Juneau RD	**1,238**
Mainland	1,238
Ketchikan Misty Fjords RD	**85,852**
Duke Is.	15
Gravina Is.	2,080
Mainland	46,956
Revillagigedo Is.	36,801
Petersburg RD	**193,666**
Kuiu Is.	79,494
Kupreanof Is.	91,823
Mainland	10,636
Mitkof Is.	8,782
Woewodski Is.	2,932
Sitka RD	**129,781**
Baranof Is.	59,032
Chichagof Is.	45,431
Kruzof Is.	25,318
Thorne Bay RD	**82,469**
Heceta Is.	1,536
Kosciusko Is.	14,780
Prince of Wales Is.	66,153
Wrangell RD	**79,912**
Etolin Is.	28,348
Mainland	22,285
Woronkofski Is.	1,448
Wrangell Is.	12,536
Zarembo Is.	15,295

Ownership	*Cumulative Acres*
Native	**35,825**
Admiralty Is.	55
Annette Is.	2,367
Baranof Is.	381
Chichagof Is.	1,077
Dall Is. & Long Is.	1,286
Heceta Is.	6
Kosciusko Is.	543
Kruzof Is.	135
Kuiu Is.	657
Kupreanof Is.	5,454
Mainland	1,783
Prince of Wales Is.	19,973
Revillagigedo Is.	2,107
State & Private	**35,921**
Admiralty Is.	21
Baranof Is.	4,313
Chichagof Is.	1,107
Dall and Long Is.	51
Etolin Is.	20
Gravina Is.	1,933
Heceta Is.	63
Kosciusko Is.	290
Kruzof Is.	397
Kuiu Is.	1,915
Kupreanof Is.	3,026
Mainland	4,165
Mitkof Is.	2,530
Prince of Wales Is.	8,864
Revillagigedo Is.	4,946
Woewodski Is.	9
Wrangell Is.	2,082
Zarembo Is.	189
Grand Total	**693,596**

STATUS OF INVASIVE PLANTS

Stream Watch volunteers and members of the KP-CWMA band together to clip reed canarygrass seed heads within the Homer Electric Association powerline corridor. Courtesy photo by Maura Schumacher.

2020 INVASIVE PLANTS UPDATES

Tongass National Forest

Southeast Alaska was exceptionally rainy this year, which hampered invasive plant treatment activities. Despite the weather and COVID-19, the Tongass National Forest completed invasive plant treatments on approximately 111 acres. Target species were reed canarygrass (*Phalaris arundinacea*), orange hawkweed (*Hieracium aurantiacum*), oxeye daisy (*Leucanthemum vulgare*), and common hawkweed (*Hieracium lachenalii*).

The Forest hired Valeria Cancino Hernandez (Figure 40) as a botanist based in Ketchikan. She arrived in Ketchikan in May, previously having worked as the Invasive Plant Program Lead at Joshua Tree National Park in southern California for three years. Before that, she was with the BLM in eastern Washington working as a biological science technician with a focus on plants. Her degree is in Plant Science from Purdue University in Indiana. Her favorite plant family is either Boraginaceae or Brassicaceae. As a botanist, Valeria will be working on invasive species as part of her regular duties. Welcome, Valeria!

Figure 40. Valeria Cancino Hernandez, new botanist located on the Ketchikan Misty Fjords Ranger District. Courtesy photo by Valeria Cancino Hernandez.

Chugach National Forest

Staff on the Chugach National Forest treated approximately 177 acres of invasive plants. High priority species that were treated included European bird cherry (*Prunus padus*), orange hawkweed, reed canarygrass, white sweet clover (*Melilotus albus*), bird vetch (*Vicia cracca*), oxeye daisy, and *Elodea* spp.

One project to highlight is a large cooperative effort to treat an infestation of reed canarygrass along a powerline corridor near Cooper Landing in close proximity to a prized salmon fishing site on the Russian River. In early 2019, the Forest Service was working with Homer Electric Association on a reed canarygrass treatment plan associated with a permit renewal. However, in the same year, the Swan Lake Fire erupted and a fire line was built through the infestation. In 2020, support from Burned Area Emergency Response funds, as well as multiple partners, including the Chugach National Forest, Kenai Watershed Forum, Kenai Peninsula Cooperative Weed Management Area, Homer SWCD, and Homer Electric Association, coordinated to treat this infestation. Throughout the summer of 2020, the following integrated weed management treatments were conducted: mowing, herbicide application, and seed head clipping (Figure 41). Although a lot of progress was made on this infestation, future work will still be needed to treat small, scattered populations.

Figure 41. Stream Watch volunteers and members of the Kenai Cooperative Weed Management Area complete a seed head clipping treatment on reed canarygrass in the Homer Electric Association powerline corridor. Courtesy photo by Maura Schumacher.

Partner Updates

2020 Alaska Invasive Plant Mini-Grants

Another year of Alaska's Invasive Plant Mini-Grant program was successfully implemented through an agreement with R10 FHP and the Copper River Watershed Project, who administer the Mini-Grants. This program supplies funds to non-federal organizations targeting invasive terrestrial plants that are ranked "60" or higher in the Alaska Invasive Plant Ranking System. With funding from the Mini-Grant program, organizations conducted outreach on invasive plants in their local communities, surveyed new areas, and manually or chemically treated infestations. Eight projects were funded in 2020.

Tyonek Tribal Conservation District (TTCD)

TTCD proposed treatment to eradicate isolated infestations of high priority invasive species along the roadways between Tyonek and Beluga on the western side of the Cook Inlet. They performed surveys and Integrated Pest Management (IPM) treatments on orange hawkweed, white sweetclover, oxeye daisy, and butter and eggs (*Linaria vulgaris*). TTCD also designed boot brushes for placement in Beluga on Hilcorp managed properties.

Kodiak Soil and Water Conservation District (SWCD)

Kodiak SWCD focused on early detection rapid response to control or eradicate small infestations of high priority plants such as oxeye daisy, orange hawkweed, Bohemian knotweed (*Fallopia* x*bohemica*), and reed canarygrass along Alaska Department of Transportation and Public Facilities (AKDOT&PF) right-of-way sites with IPM treatments. Kodiak SWCD also planned on distributing educational materials at events, but due to COVID-19, events were cancelled. Instead, Kodiak SWCD conducted education and outreach through signs, online outreach, and brochures.

Citizens Against Noxious Weeds Invading the North (CANWIN)

CANWIN proposed to survey and control four infestations of spotted knapweed (*Centaurea stoebe*) along Turnagain Arm. The infestations covered roughly a 4-mile area along the highway and railroad, and were treated with the herbicide Milestone®. Surveys were performed in the adjacent areas.

Metlakatla Indian Community (MIC)

MIC conducted a targeted effort to reduce the size of existing populations of reed canarygrass. Approximately 16 acres of reed canarygrass were treated through physical and cultural methods.

Copper River Watershed Project

The Copper River Watershed Project conducted surveys and IPM treatments of reed canarygrass, orange hawkweed, oxeye daisy, Bohemian knotweed, white sweetclover, and bird vetch throughout the Copper River watershed. They also proposed to distribute native wildflower seed packets, host the Annual Copper Basin Weed Smackdown, and create and launch a Copper River Watershed interactive data web page on Anecdata.org. Due to COVID-19, the weed event could not be held so the organization encouraged local weed pulls and surveys using the Anecdata page virtually.

Homer Soil and Water Conservation District (SWCD)

Homer SWCD continued IPM treatments of orange hawkweed in Girdwood Valley, surveyed the southern Kenai Peninsula for European bird cherry, and designed and installed two boot brush stations in Homer. Part of the European bird cherry surveys included partnering with landowners through a cost-share program to supplement the purchase of native plants to replace European bird cherry (with removal at owners' expense). Lastly, Homer SWCD initiated a willow-staking project to control reed canarygrass in Jakolof Bay.

Southeast Alaska Watershed Coalition (SAWC)

SAWC controlled a large infestation of garlic mustard (*Alliaria petiolata*) in downtown Juneau with IPM methods. The infestation covered approximately 7,000 square feet and was one of only two known infestations of garlic mustard in the state. SAWC also controlled 2.75 acres of knotweed in AKDOT&PF road rights-of-way, on borough lands, and on private parcels in the Borough of Petersburg.

Kenai Watershed Forum

Kenai Watershed Forum proposed to perform a comprehensive survey for European bird cherry on the Kenai Peninsula; partner with landowners to make treatment recommendations of European bird cherry; and treat bird vetch, white sweetclover, common tansy (*Tanacetum vulgare*), hemp nettle (*Galeopsis tetrahit*), and reed canarygrass with IPM methods. Education and outreach tasks included boot brush installation on the Kenai Peninsula (Figure 42), community weed pulls, and an educational series within multiple schools. With school closures due to COVID-19, educational materials were prepared and provided to schools and home school groups for fall lessons.

Figure 42. Newly installed boot brush and informational kiosk at the Homer Harbor. Courtesy photo by Katherine Schake.

Anchorage Parks Foundation

Forest Health Protection partnered with the Anchorage Parks Foundation (APF) to conduct invasive species work on public lands within the Anchorage municipality. Through their agreement, the APF has contracted invasive species work with CANWIN and their contractor Alien Species Control. Utilizing IPM techniques, CANWIN controlled the following species throughout the Municipality of Anchorage: European bird cherry, spotted knapweed, creeping thistle (*Cirsium arvense*), orange hawkweed, white sweetclover, bird vetch, and reed canarygrass. A total of 159 acres were treated this year.

There were some notable highlights from IPM treatments.

- This may be the final year that European bird cherry IPM treatments are warranted in Valley of the Moon Park. A final determination will be made after surveys conducted next year. Local residents near the Chester Creek Trail have expressed gratitude to CANWIN crews for their work on controlling European bird cherry. This was the second year of treatment on a site that covered about 22 acres.

- Spotted knapweed treatments along Turnagain Arm (funded by a Mini-Grant) appear to have been successful. This infestation was first treated in 2019, and field visits this summer showed very few plants in known locations. However, new locations were found, which have since been treated. Spotted knapweed is a highly invasive plant that is still rare in Alaska and has been listed as the highest priority for eradication for the Anchorage Cooperative Invasive Species Management Area (CISMA).

- Creeping thistle has been a top priority for management and eradication by the Anchorage CISMA. This year creeping thistle management was prescribed at 18 sites in the AKDOT&PF rights-of-way throughout the municipality (including Girdwood).

Part of the invasive species duties under this agreement have been to lead the Anchorage CISMA. A major accomplishment this year was drafting the Anchorage Invasive Species Management Plan, which was reviewed by Anchorage CISMA members and will be finalized this winter.

A big change this season was a lack of in-person volunteer events due to COVID-19. To accommodate safety concerns, the Anchorage CISMA proposed a socially distanced plan for their largest volunteer event, the Anchorage Invasive Weed Smackdown, which had attracted 100 volunteers in the past. Unfortunately, the Municipality of Anchorage did not approve the plan because they were concerned unsupervised volunteers could cause natural resource damage. Undeterred, the Anchorage CISMA reorganized the event to a creative virtual Invasive Weed Smackdown through which local residents were encouraged to share invasive species outreach information via social media (Figure 43) or other methods and report on their activities. Ten groups signed up for this event and approximately 22 people participated. This virtual event took place from August 15 through September 20, 2020. One unique entry was from artist Tom Chung, along with six former University of Alaska painting students, who painted a 12 foot tall window-shaped mural as part of the Anchorage Museum mural project in downtown Anchorage (Figure 44). Participants received a t-shirt and there was a random drawing to win a cutting board made from chokecherry wood by a local artist (Figure 45).

Figure 43. Paul Brusuelas' Facebook post during the Virtual Anchorage Weed Smackdown. Courtesy photo by Paul Brusuelas.

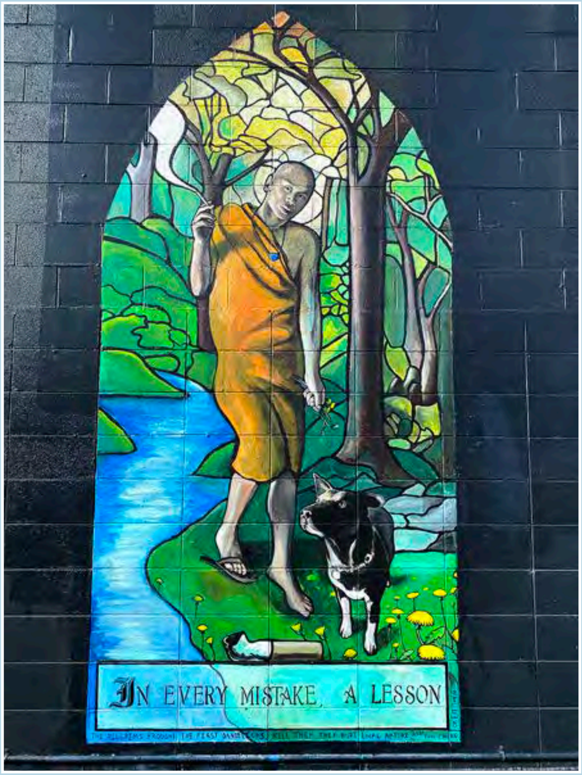


Figure 44. A 12' tall mural painted by Tom Chung and UAA painting students. The mural, intended to raise awareness of climate change, was also a Weed Smackdown virtual contest entry. The mural depicts Buddha standing in a field of dandelions with the caption: In Every Mistake, A Lesson. The pilgrims brought the first dandelions, kill them, they hurt local nature. Or eat them. Courtesy photo by Tom Chung.

Figure 45. Handcrafted cutting board made with chokecherry wood. Courtesty photo by Tim Stallard.

University of Alaska Fairbanks Cooperative Extension Service (UAF CES)

Forest Health Protection has an agreement with UAF CES to support their Integrated Pest Management program for Alaska. Through this agreement, the IPM program addresses forest health and invasive species topics through community education, disseminating information about on-going surveys, and documentation of invasive plants and forest pest locations and trends.

There were some notable highlights under this agreement this year. A record number of invasive plant locations were submitted via the mobile application, AK Weeds ID. Information on the app can be found online here: https://apps.bugwood.org/apps/alaska. Through their online pest reporter, email, and phone reports, staff at UAF CES worked with the public on invasive plant identification and weed management strategies with 76 people.

The biggest challenge for UAF CES was having to move numerous classes and workshops to an online platform due to COVID-19. One benefit to online learning was expanding their reach to more people over a larger geographic area. For example, UAF CES attracted 85 participants in the Southeast Master Gardener Conference that extended participation well beyond the Juneau area. UAF CES also hosted a bird vetch control workshop with 53 participants statewide.

By far the largest online event was the annual Alaska Invasive Species Partnership (AKISP) Workshop, which had originally been planned as a multi-day event in Anchorage, AK in October 2020. Organizers changed the workshop format and content to three half-day sessions that were offered online with free registration, attracting over 165 registrants. Presentations addressed controlling invasive chokecherry (*Prunus virginiana*), orange hawkweed, and northern pike, evaluation of the impacts of Elodea, and invasive species initiatives on lands managed by the Department of the Interior. Certified applicators received two Continuing Education Units for attending this workshop.

Every year, awards have been presented during the annual AKISP workshop and this year was no exception with four individuals being awarded. John Morton, retired biologist from the Kenai National Wildlife Refuge, received the Lifetime Achievement award. Tim Stallard of Alien Species Control was given the Leadership/Outreach award. Erick White from the Alaska Railroad was given the award for Volunteerism. Rose Masui from the Kachemak Bay National Estuarine Research Reserve received an award for Outstanding Contribution to Marine Invasive Species Outreach and Community-Based Early Detection Monitoring. Congratulations to all award winners!

State Grants

Forest Health Protection and the Alaska Division of Forestry, Urban and Community Forestry Program (CFP) have grant monies for local governments and non-profits to remove invasive trees. There are two programs: one focused on European bird cherry and/or chokecherry trees and the other focused on other invasive trees. In 2020, CFP began awarding funds to organizations through a competitive process. To date, grant recipients include Homer Soil and Water Conservation District, Southeast Alaska Watershed Coalition, and Talkeetna Community Council Inc.

Publications

This year, two popular brochures were updated and re-printed. First, the highly popular “Selected Invasive Plants of Alaska” pocket guide (Figure 46) was updated with new species, photos, and content. New additions to the pocket guide include giant hogweed (*Heracleum mantegazzianum*), creeping buttercup (*Ranunculus repens*), Elodea, and European mountain-ash (*Sorbus aucuparia*). The other update was to the European bird cherry brochure, with new photos and content. These brochures have been distributed to organizations throughout the state and are free to those interested.

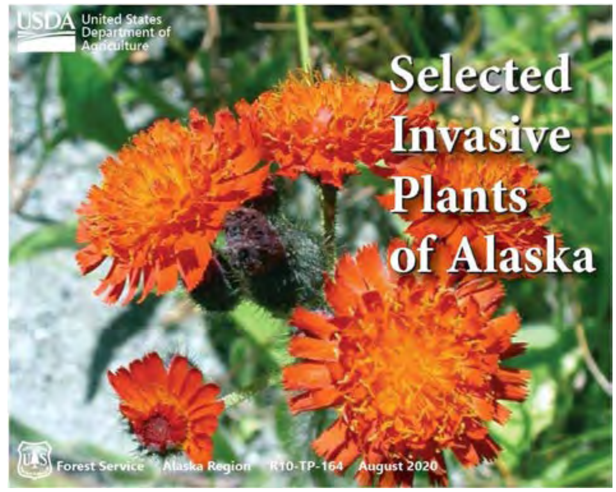


Figure 46. Cover of the updated “Selected Invasive Plants of Alaska” pocket guide.

Other Updates

There are many invasive species activities that have occurred throughout Alaska that have not been funded by State and Private Forestry, Forest Health Protection through formal agreements. Many of these activities have been conducted by local Cooperative Weed (Invasive Species) Management Areas, Soil and Water Conservation Districts, or other organizations. Often, staff from these organizations coordinate and consult with invasive species experts across the state to work more effectively. The Alaska Invasive Species Partnership (AKISP) has helped facilitate this coordination through monthly calls and a vast listserv that has increased statewide communication. Funding for these activities has been through a variety of means, such as other organizations, agencies, or grants. The following updates have been provided by local organizations.

Figure 47. Herbicide treatment in Totchaket Slough. Courtesy photo by Aditi Shenoy.

Fairbanks/Interior Alaska

The Fairbanks Soil and Water Conservation District (FSWCD) has been a lead group that conducted invasive plant work in this region. They have focused on controlling Elodea for the past several years. During the 2020 season, the FSWCD team worked on Elodea eradication efforts in six water bodies in Interior Alaska. FSWCD and partners completed herbicide treatments (Figure 47) to eradicate invasive Elodea in Chena Slough, Totchaket Slough, Chena Lake, Bathing Beauty Pond, Birch Lake, and Hot Springs Slough in Manley. Elodea has been nearly eliminated in Totchaket Slough and Chena Slough, which have been treated for 3 and 4 years, respectively.

The FSWCD invasive species team conducted early detection surveys for Elodea in high risk lakes, floatponds, and sloughs near Fairbanks, Nenana, Manley, and Delta Junction (Figure 48). As a result, they detected three new Elodea infestations in Harding Lake, Piledriver Slough, and Chisolm Lake. All of these water bodies are in the vicinity of known Elodea infestations that are currently being treated. Treatment plans for the new infestations are being developed.

Figure 48. Elodea early detection surveys. Courtesy photo by Aditi Shenoy.

Southcentral Alaska/Kenai Peninsula
Much work in this region has been conducted by the Kenai Cooperative Invasive Species Management Area (CISMA), the Homer Soil and Water Conservation District, and the Kenai Watershed Forum. Emphasis on European bird cherry treatment in this region has been highlighted in an essay on page 13.

The Kenai Watershed Forum (along with CISMA partners) surveyed for and treated infestations of reed canarygrass across the Kenai Peninsula. Infestations were found surrounding several lakes, trails, roads, and trailheads (Figure 49). One notable finding resulted from surveys on the North Rd. Ext./Pipeline Access Rd. where extensive infestations were found and documented.

Numerous infestations of reed canarygrass were treated this summer. In addition to the treatment discussed above on the Homer Electric Association powerline corridor near Cooper Landing, another Homer Electric Association site at the Bradley Lake hydroelectric facility was found and treated in 2020 (Figure 50), demonstrating an early detection/rapid response scenario. Other treatment sites included lakesides (Figure 51), AKDOT&PF right-of-way sites, and gravel pits.

Southeast Alaska
Southeast Alaska Watershed Coalition (SAWC) has led many activities in Southeast Alaska. This year, their work has been focused in the Juneau area and control activities have targeted orange hawkweed, Bohemian knotweed, reed canarygrass, and European bird cherry.

SAWC treated a large orange hawkweed infestation in the Eagle Beach State Recreation Area in an uplifted beach habitat that is rare in Southeast Alaska. This site is used as a picnic area where human activity could spread this species to new locations.

Coordinated efforts with SAWC, AKDOT&PF, and the City and Borough of Juneau were instrumental in eradicating an infestation of bohemian knotweed near the Twin Lake city park. Treatments to eradicate this infestation started in 2018 with the last treatments occurring this year. Youth from the Zach Gordon Youth Center and members of the Thunder Mountain High School Honor Society planted 150 native shrubs to restore native species to the site (Figure 52, page 50). Other knotweed treatments occurred on over 100 private properties and infestations located on municipal and AKDOT&PF right-of-way sites in Juneau.

SAWC controlled reed canarygrass infestations in the lower Jordan Creek Greenbelt near Juneau International Airport, in the western part of the Mendenhall Wetlands State Game Refuge, at Fish Creek Park on Douglas Island, and in AKDOT&PF right-of-way sites along north Glacier Highway.

SAWC treated more than 400 invasive *Prunus* spp. trees with herbicide in Juneau in 2020. Herbicide was applied in shells inserted into the phloem or by using the hack and squirt technique, wherein the bark is wounded to expose the inner

Figure 49. Young reed canarygrass in a low lying, wet area of the North Road Extension/Pipeline Access ATV trail construction zone. Courtesy photo by Maura Schumacher.

Figure 50. Reed canarygrass encroaching on a stream at Bradley Lake hydroelectric facility. Courtesy photo by Maura Schumacher.

Figure 51. Reed canarygrass along Stormy Lake. Courtesy photo by Maura Schumacher.

Figure 52. Members of the Thunder Mountain High School Honor Society plant native shrubs on a former knotweed infestation site. Funding for this restoration project was provided by the Avista Foundation. Courtesy photo by John Hudson.

tissue for herbicide application, thus minimizing herbicide use and limiting damage to surrounding vegetation. Most of the trees were in a large infestation in the Eagle Beach State Recreation Area. Additional *Prunus* spp. and European mountain-ash trees were treated in riparian areas along Duck and Jordan Creeks, in the Mendenhall Wetlands State Game Refuge, and in downtown Juneau. SAWC staff also mapped more than 1500 mountain-ash trees in Juneau in 2020. This fall a local woodturner cut down five mountain-ash and cherry trees that were killed with herbicide and will use the wood for woodworking projects.

Other organizations and groups have also worked on invasive species in Southeast Alaska. One group is the Ketchikan Tansy Pullers who are dedicated to controlling tansy ragwort in the Ketchikan area.

The Metlakatla Indian Community (MIC) has been a leader in invasive species management on Annette Island. This year COVID-19 significantly impacted their annual work. Nevertheless, MIC leveraged funds from the Mini-Grants, Bureau of Indian Affairs, and other sources to complete a comprehensive survey of all known and potentially unknown invasive species. Additionally, MIC planned control work on reed canarygrass in targeted areas with a focus on the Annette Bay Pass Road area. Although not all of the work was completed due to COVID-19, MIC was still able to map 165 acres of invasive species and they have plans to use these detailed maps to prioritize their work in 2021.

Statewide Updates

Alaska Division of Agriculture (AKDoAg) invasive plant specialists have been working on Elodea, specifically in the Municipality of Anchorage and in the Matanuska-Susitna region. Activities accomplished this year include surveys, treatments, and outreach. Specifically, AKDoAg surveyed six lakes on the road system within the Municipality of Anchorage and 13 road system lakes and Alexander Creek within the Matanuska-Susitna Borough. The highlight from these surveys is that no Elodea has been detected!

Treatments have taken place in Little Survival Creek, Lake Hood, and Jewel Lake in Anchorage and Alexander Lake, Sucker Lake, and Big Lake in the Matanuska-Susitna Borough. Treatments appear to be highly effective with little to no Elodea found in treated water bodies.

For outreach, AKDoAg installed signs with a “Clean Drain Dry” message at state park boat launches at six Matanuska-Susitna lakes. “Clean Drain Dry” is a national campaign to educate outdoor recreational users on how to prevent the spread of invasive species. Another outreach highlight from the State is a short video they produced on their Elodea work (https://www.youtube.com/watch?v=7XjDiCEtJng).

University of Alaska Fairbanks, Cooperative Extension Service staff have been busy with invasive plant work beyond their work conducted under the agreement they have with Forest Service, State & Private Forestry. They have initiated long term studies on persistent herbicides at the Fairbanks and Matanuska Experiment stations. These studies will focus on herbicides aminopyralid and clopyralid to determine how to use their persistence to facilitate production of weed-free straw.

In addition, UAF CES is expanding *Prunus* spp. control work to determine how non-target impacts of herbicides change with varying densities of *Prunus* spp. treated with basal bark treatments. Experimental plots (Figure 53) have been established in Fairbanks and Palmer and wildland sites in Anchorage and Fairbanks will be selected in the future.

Figure 53. *Prunus* spp. plot that was planted by Gino Graziano of the UAF CES. Courtesy photo by Gino Graziano.

STATUS OF INSECTS

Social media reports alerted FHP to western tent caterpillars in Ketchikan, Hyder and Annette Island. Western tent caterillars are not known to occur in Alaska, however are native to nearby British Columbia. USDA Forest Service photo by Tom Heutte.

2020 INSECT UPDATES

Hardwood defoliators – External leaf feeding

Aspen Defoliation
Sunira verberata (Smith)

Reports were received in late May and early June of caterpillars feeding on aspen in the Sterling area, as well as along the Marsh Lake Trail in the Kenai National Wildlife refuge. Additionally, on June 18, areas of intense hardwood defoliation were found along Juneau Creek Road just west of Cooper Landing. Quaking aspen were defoliated the most, but birch, willow, black cottonwood, wild rose, highbush cranberry, and russet buffaloberry were also impacted. Darkly colored caterpillars with diamond-shaped markings were collected from the affected plants (Figure 54). Collected specimens were identified by LifeScanner (http://lifescanner.net) as *Sunira verberata* using DNA-based identification.

Figure 54. The generalist hardwood defoliator, *Sunira verberata*, was found defoliating aspen, birch, and other tree and shrub species along Juneau Creek Road on the Kenai Peninsula. USDA Forest Service photo.

Balsam Poplar Leaf-Folding Sawfly
Phyllocolpa excavata (Marlatt)

Leaf-folding in seedling- and sapling-sized balsam poplar and black cottonwood was observed in many areas in Interior Alaska (Elliot Highway roadside sites from Minto and Livengood, south along the Richardson and Alaska Highways to Tok, on Chena Hot Springs Road) and at one site in Southcentral Alaska, near McCarthy. Both damage (Figure 55) and the causal agent (Figure 56) were observed. Prior to 2020, Forest Health Protection (FHP) observed similar damage in balsam poplar seen at the Vor Lake seaplane base in Bettles in 2018; however, no damage agent was found.

Larvae were collected from affected leaves along the McCarthy road and the Elliot Highway north of Livengood. A photograph of a larva was posted on an iNaturalist forum (https://www.inaturalist.org/observations/55720699) and identified as *Phyllocolpa* sp. (Hymenoptera: Tenthredinidae) by a leafminer specialist. Larvae collected from these locations were submitted to LifeScanner (http://lifescanner.net) and identified as *Phyllocolpa excavata*, a leaf-folding sawfly that uses *Populus* and *Salix* species as hosts in Alaska (Goulet 1992; Collet 2004). While this species of sawfly is not new to Alaska, it most likely goes unnoticed when population levels are low.

Figure 55. Underside (L) and top (R) view of a balsam poplar leaf showing the edge fold created by *Phyllocolpa excavata.* USDA Forest Service photo.

Figure 56. Leaf fold opened up to expose the *Phyllocolpa excavata* larva. USDA Forest Service photo.

Birch Aphid

Euceraphis betulae (Koch)

Birch aphid is common throughout the state and heavy damage is occasionally documented in Southcentral and Interior Alaska. In the mid-1970s, 500,000 acres of damaged birch with heavy aphid populations were recorded in the Palmer and Chickaloon areas. More recently, smaller defoliation events presumed to be aphid-caused were observed in Slana in 2014 and at Sevenmile Lake in 2017. In the spring of 2020, aphid populations increased in some Interior birch stands and early season feeding on buds caused failed leaf production or distorted, discolored, and tattered leaves (Figure 57) and premature leaf drop (Figure 58).

In late May, FHP conducted a site visit following several reports of extensive birch defoliation along the Richardson Highway in the Birch Lake area. Birch foliage appeared tattered and discolored, consistent with early season aphid feeding. This damage was mostly concentrated in the upper crowns. In late June, several stands of birch along Johnson Road in Salcha were observed during ground surveys with tattered and discolored foliage and defoliated tops consistent with early season aphid feeding. Damage ranged from minor to complete birch defoliation with some minor impacts to alder species. Large populations of birch aphids were also present on the undersides of most accessible birch and alder leaves. Birch aphid activity was also common around Fairbanks and all roads throughout the Interior, as well as in the Copper River Valley, along Turnagain Arm, and near Sterling. Most birch aphids observed were at trace to moderate levels, with the exception of the heavily defoliated areas mentioned above. Several birch trees at each site re-flushed in small sporadic clumps, though no wholesale re-flush of defoliated trees were seen (Figure 59). Over 850 acres of heavy birch defoliation was mapped along the Richardson Highway near Birch Lake and along Johnson Road in Salcha during the site visits described above. Birch aphid was confirmed as the causal agent on over 200 of those acres during ground surveys of accessible stands where moderate to heavy populations were present.

Figure 57. Early season aphid feeding during bud break can cause distorted and tattered leaves like those seen here. Aphids were still very abundant on these leaves in late June. USDA Forest Service photo.

Figure 58. Heavy aphid feeding early in the season caused premature leaf drop at many sites along Johnson Road in Salcha. USDA Forest Service photo.

Western Tent Caterpillar

Malacosoma californica (Packard)

In June 2020, FHP noted reports on social media about a large population of caterpillars aggregating in silken tents in red alder along the bike path in the Mountain Point area of Ketchikan. The species was initially identified based on photographs as western tent caterpillar. Thanks to our colleagues on the Ketchikan Ranger District, specimens were collected and reared to adults to confirm the identification. Seven additional observations of western tent caterpillars were confirmed in Ketchikan and Hyder from reports on iNaturalist.

Figure 59. Small tufts of leaves seen later in the summer show that some birch re-flushed partially. USDA Forest Service photo.

Western tent caterpillars are not known to occur in Alaska, however, their native range does extend into nearby British Columbia. It is likely their establishment in Ketchikan and Hyder is a result of range expansion. Further surveys are needed to confirm this hypothesis. While feeding damage was moderate, the large, showy caterpillars and their tents garner attention (See Status of Insects photo, page 51).

Rusty Tussock Moth
Orgyia antiqua (L.)

Rusty tussock moth was reported at numerous locations across the state in 2020 (Figure 60). Notably high populations occurred in Southcentral Alaska, including 35 acres of low-level defoliation recorded near Hatcher Pass. Rusty tussock moth caterpillars were prevalent along the road system within the Matanuska-Susitna Borough, though defoliation was generally minimal; however, substantial defoliation was reported in some areas at, or above, treeline. Concern and reports were especially high among berry pickers who reported the caterpillars feeding on the leaves of blueberries, cloudberries, currants, and highbush cranberries, among others. This generalist defoliator was also reported feeding on alder, willow, birch, cottonwood, spruce, and numerous garden plants.

With the cancellation of aerial surveys in 2020, staff were limited in their survey coverage for this insect. To supplement the survey effort, a request for reports of defoliation from this insect was distributed through social media. While most observations were from Southcentral, reports were also received from the Bethel area and near Fairbanks, as well as on the Seward Peninsula, where an outbreak of rusty tussock moth occurred in 2019. Thirty-two research grade observations of the rusty tussock moth were recorded in iNaturalist.

Rusty tussock moth is Holarctic in its distribution, with two subspecies occurring in the state, *Orgyia antiqua nova* (Fitch, 1863) and *Orgyia antiqua argillacea* (Ferguson 1978). Outbreaks of rusty tussock moths occur periodically and are typically short lived.

Hardwood defoliators – Internal leaf feeding

Aspen Leafminer
Phyllocnistis populiella Chambers

Aspen leafminer was recorded on quaking aspen (Figure 61) and balsam poplar (Figure 62, page 56) during ground surveys along the entire road system north of the Alaska range and south into the Copper River Valley. Damage was also recorded south along the Parks Highway into the Matanuska-Susitna Valley. Thirteen research grade observations were reported in iNaturalist from Fairbanks, Chicken, and Anchorage.

Aspen leafminer damage was recorded across all size classes of quaking aspen from seedling to poletimber (up to 10” in diameter) and with a fairly even spread across areas surveyed. Trace to heavy damage was also spread across much of the surveyed area, though only trace and light levels were seen on the Richardson Highway south of Glennallen. ems affected in all areas ranged from a few trees to greater than 30.

Figure 60. A rusty tussock moth female lays eggs on a branch end. Females are stout, hairy, wingless moths that are active in late summer and early fall. The eggs will overwinter and hatch the following spring. USDA Forest Service photo by Alex Wenninger.

Figure 61. The typical damage signature of aspen leafminer on quaking aspen consists of silvery grey foliage with distinct serpentine galleries visible. USDA Forest Service photo.

INSECTS

Leafminer damage was recorded at trace to light levels on balsam poplar seedlings, although it was also quite evident on some saplings. Similar damage has been observed on black cottonwood in Southcentral and Southeast. However, there has been some uncertainty over the taxonomic identity of the damage agent for both tree species and further investigation is planned (see Black Cottonwood Leafminers below).

During the scan and sketch survey almost 39,000 acres of moderate to heavy aspen leafminer damage was recorded. This is a fraction of the acres normally mapped; however, only 2.4 million acres were surveyed in this manner, accounting for one tenth the number of acres regularly surveyed. Almost all the damage was mapped in the Interior and north of the Alaska Range, with less than 50 acres mapped in Southcentral near Kenai and Soldotna.

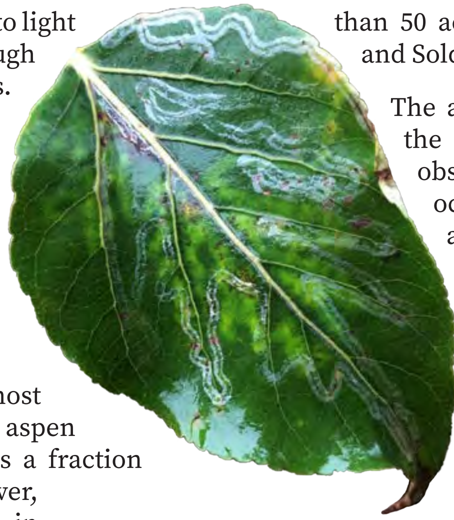


Figure 62. Leafminer symptoms on balsam poplar will occasionally present with the silvery grey cast that is typically seen on quaking aspen. USDA Forest Service photo.

The amount and extent of the damage across the Interior was not a surprise since it was observed in all areas where it has historically occurred with one exception; there was a lack of damage in the Copper River Valley from about Paxson Lake south to the Tiekel River. Aspen leafminer is typically very common along the entire road system in the Copper River Valley, and it is not unusual to have moderate to heavy activity throughout the area. Some damage was mapped using scan and sketch survey in the area of Copper Center, but very little was found during ground surveys. The apparent collapse of aspen leafminer populations in this area was unexpected.

Birch leafminers

Fenusa pumila Leach
Heterarthrus nemoratus (Fallén)
Profenusa thomsoni (Konow)
Eriocrania sp. Zeller

In late May and early June, leaf mines on birch were observed earlier in the season than expected. Upon further investigation, mines were also found on alder. Larvae were extracted from the leaves and sent to LifeScanner for DNA-based identification. The leafminer was identified as the genus *Eriocrania* (Lepidoptera: Eriocraniidae) based on DNA analysis and comparisons in the Barcode of Life Data Systems and in consultation with a leafminer specialist. Notably, these specimens may represent an undescribed species. Further investigation of these occurrences is planned for 2021.

Birch leafminers were observed during all ground-based survey efforts in 2020; however, it was undetectable during scan and sketch surveys in areas where it is known to occur.

Profenusa thomsoni and *Heterarthrus nemoratus* are the most commonly observed leafminers in birch in Southcentral and Interior. In Southcentral, leafminer damage was noted as low overall for both species during ground surveys. In the Interior, *P. thomsoni* damage was variable, ranging from trace to high levels of damage, while *H. nemoratus* damage was observed at trace to low levels. During ground surveys, approximately 2,800 acres of leafminer damage were mapped along the Richardson Highway south of Fairbanks and along the Parks Highway from around Talkeetna south to about Houston.

Black Cottonwood Leafminers

Phyllocnistis sp. Zeller

Black cottonwood in the Exit Glacier area near Seward had moderate leafminer damage, with silvery and tannish-yellow crowns. It is rare to see leafminer activity in black cottonwood great enough to discolor the crowns (Figure 63, page 57). The damage is similar to that of aspen leafminer in balsam poplar in the Interior. There is uncertainty over whether the species are the same and further investigation is planned. Larvae were sent for DNA analysis using LifeScanner and were identified as *Phyllocnistis* sp.

Ground survey efforts identified fifteen sites with leafminer activity on black cottonwood spread across the Kenai Peninsula, as well as one site at Bird Point along Turnagain Arm and one site in Juneau. Generally, most sites had trace levels of within-tree damage, and trees with observed damage were mostly seedling- and sapling-sized. The exception was the Exit Glacier area, which had moderate to high damage occurring across a range of tree sizes. This damage was observed at the survey sites, as well as along Exit Glacier Road.

Figure 63. Close-up and landscape level views of leafminer damage on cottonwoods near Exit Glacier at the end of August. The crowns appeared somewhat silvery. USDA Forest Service photo.

Figure 64. Moderate levels of willow leafblotch miner observed on the Chena Hot Springs Road. Trace to severe levels were seen throughout many areas of the Interior, which has been a common occurrence most years. USDA Forest Service photo.

Figure 65. Heavy levels of willow leafblotch miner observed at a scenic overlook south of Glennallen along the Richardson Highway. USDA Forest Service photo.

Willow Leafblotch Miner
Micrurapteryx salicifoliella (Chambers)

Historically, ground observations demonstrate that willow leafblotch miner is present throughout the Interior and more widespread than is indicated during aerial surveys. In 2020, ground surveyors recorded over 400 acres of willow leafblotch miner activity along all Interior roads north of the Alaska Range where willow was present, though it proved to be difficult to locate during the scan and sketch survey. Willow leafblotch miner was also observed in some areas in the Copper River Valley. Damage appears as orange and brownish-grey blotches on foliage (Figure 64) and was observed on shrub-size willow with stems up to 4” in diameter. At most sites, damage was recorded on multiple stems, with some sites showing over 30 stems affected. Levels of observed damage ranged from trace to moderate with a small number of sites featuring heavy damage.

It is unusual to have a willow leafblotch miner outbreak in Southcentral, but in 2020, moderate to heavy damage was found during ground surveys in the Copper River Valley along the Richardson Highway in the Glennallen area (Figure 65) while moderate damage was recorded along the Edgerton Highway. During the 2019 aerial surveys, 100 acres of damage were mapped in the Copper River Valley, but none had been mapped in Southcentral for many years prior.

Apart from the Copper River Valley, damage levels observed on the ground in 2020 were similar to those seen on the ground in recent years, although it is hard to extrapolate how severe and widespread willow leafblotch miner was across the state this year.

Softwood defoliators

Spruce aphid
Elatobium abietinum (Walker)

No notable spruce aphid activity was reported during 2020, however 60 acres of damage were recorded on Douglas, Vank, Woronkofski, and Zarembo Islands. Ground surveys in Homer and Juneau in October confirmed that spruce aphid activity was low in both areas (Figure 66). Cold winter temperatures limit aphid activity and are suspected to be keeping aphid populations in the Kachemak Bay region in check. In Juneau, spruce aphids were only found at sites that are well insulated and protected from extreme winter temperature such as the Auke Recreation Area.

Figure 66. Biological Technician Isaac Davis and Biological Scientist Isaac Dell surveyed Juneau coastal areas in October 2020 for spruce aphid. Populations were low except Auke Recreation Area, a place known to consistently have spruce aphid issues. USDA Forest Service photo by Elizabeth Graham.

Spruce budworm
Choristoneura fumiferana (Clemens)
Choristoneura orae Freeman

Spruce budworm populations were monitored in 2020 using pheromone traps at four different sites in Southcentral Alaska. The number of locations decreased from nine in 2019 due to logistical restrictions caused by the COVID-19 pandemic. Two green bucket traps were placed at each site and baited with either a *Choristoneura fumiferana* lure or a *C. orae* lure. Between the four trapping locations, the *C. orae* traps collected 238 specimens. These numbers are consistent with 2019 trap catches for the same locations. Overall, damage from spruce budworm was low for the areas surveyed in 2020.

Hemlock sawfly
Neodiprion tsugae Middleton

Hemlock sawfly activity has decreased throughout Southeast Alaska and is not expected to persist in 2021. More than 530,000 acres of hemlock sawfly defoliation damage have been mapped across Southeast Alaska since 2018. In 2021, active defoliation was recorded on over 124,000 acres during scan and sketch surveys, and mortality attributed to hemlock sawfly feeding was recorded on over 80,000 acres. Often mortality and defoliation occurred in the same area, therefore the total area attributed to hemlock sawfly damage was over 143,000 acres. Ground observations have also shown a decrease in larval activity. For more information about scan and sketch surveys, refer to Appendix I on page 66. For more detailed information on hemlock sawfly activity (see the essay on page 15).

Western blackheaded budworm
Acleris gloverana Walsingham

Western blackheaded budworm activity increased from 2019 based on ground survey data. Caterpillars feed on the buds and new growth of hemlock (Figure 67), which, in combination with the hemlock sawfly outbreak, could prove detrimental to affected trees. Survey plots located on Mitkof Island had the greatest number of western blackheaded budworm (see sawfly essay). In some locations around Petersburg, reports of caterpillars hanging from silk threads on western hemlock were received. Western blackheaded budworm moths were reported on iNaturalist in Sitka. The increased activity does not yet indicate an outbreak but should continue to be monitored.

Figure 67. Western blackheaded budworm larvae feed within hemlock buds and then move onto new needles. USDA Forest Service photo.

Bark beetles

Spruce Beetle

Dendroctonus rufipennis (Kirby)

Southcentral Alaska is estimated to be in the fifth year of a spruce beetle outbreak. The outbreak had affected at least 1.1 million cumulative acres of mixed spruce and birch forests through 2019, when a notable decline in active spruce beetle across the region was documented. Approximately 145,000 acres of spruce beetle activity was recorded in 2020, bringing the cumulative acreage affected by spruce beetle to be at least 1.2 million acres.

In 2020, Alaska Department of Natural Resources, Division of Forestry (DNR DOF) Forest Health staff were able to safely conduct site visits with landowners to assess spruce beetle activity in support of the Western Bark Beetle Initiative; 2020 was the first year of this DOF-administered cost-share program.

Region 10 FHP and DNR DOF staff were involved in two tree protection studies in 2020, both led by Dr. Christopher Fettig, of the Forest Service, Pacific Southwest Research Station. A study initiated in 2019 evaluated SPLAT-MCH (ISCA Technologies, Inc.) in combination with other semiochemicals (a form of chemical communication between organisms) as a method of repelling spruce beetles from susceptible trees. This study was completed in 2020. The second study, which began in 2018, evaluated systemic pesticide efficacy in killing spruce beetles as they attack trees and limiting the introduction of blue-stain fungi. The study trees were initially challenged by beetles in 2019 and the success of the treatments was assessed in 2020. The surviving trees will be reassessed after the 2021 spruce beetle flight period. Final results and data analysis from both studies will be forthcoming.

In place of the typical aerial surveys in 2020, an alternative strategy to survey the state's forests was developed by survey specialists from the DOF and Region 10 FHP (see Appendix I on page 66 for more detail). This alternative strategy combined road-based ground surveys, manual interpretation of high-resolution imagery, and remote sensing efforts. As a result of this alternative methodology, the data collected in 2020 lack direct comparability to that of previous years. With that in mind, we have divided this update into two subsections: ground survey, which includes data from targeted road-based surveys and general observations from the field and imagery interpretation, which includes data from the analysis of high-resolution imagery. The statewide bark beetle map (Map 31, page 61) includes data from both survey types. With no northern spruce engraver or western balsam bark beetle documented in 2020, this map includes only spruce beetle damage.

Ground Survey

Ground-based observations across the region in 2020 have confirmed that the outbreak has subsided or is persisting in the less favorable host (black spruce) in many of the areas that have been most severely impacted since the outbreak began. However, these and additional survey efforts documented continued or expanding activity along the periphery of areas previously impacted during the current outbreak. Notable areas of ongoing spruce beetle outbreak activity were documented in the Cooper Landing area, the Anchorage Municipality, and along the Parks Highway around miles 180-190, roughly near the East Chulitna Wayside. Additional scattered spruce beetle activity was documented extending north into the Denali Borough, including the Cantwell area and the western portion of the Denali Highway; the northernmost reaches of the outbreak will be closely monitored in 2021.

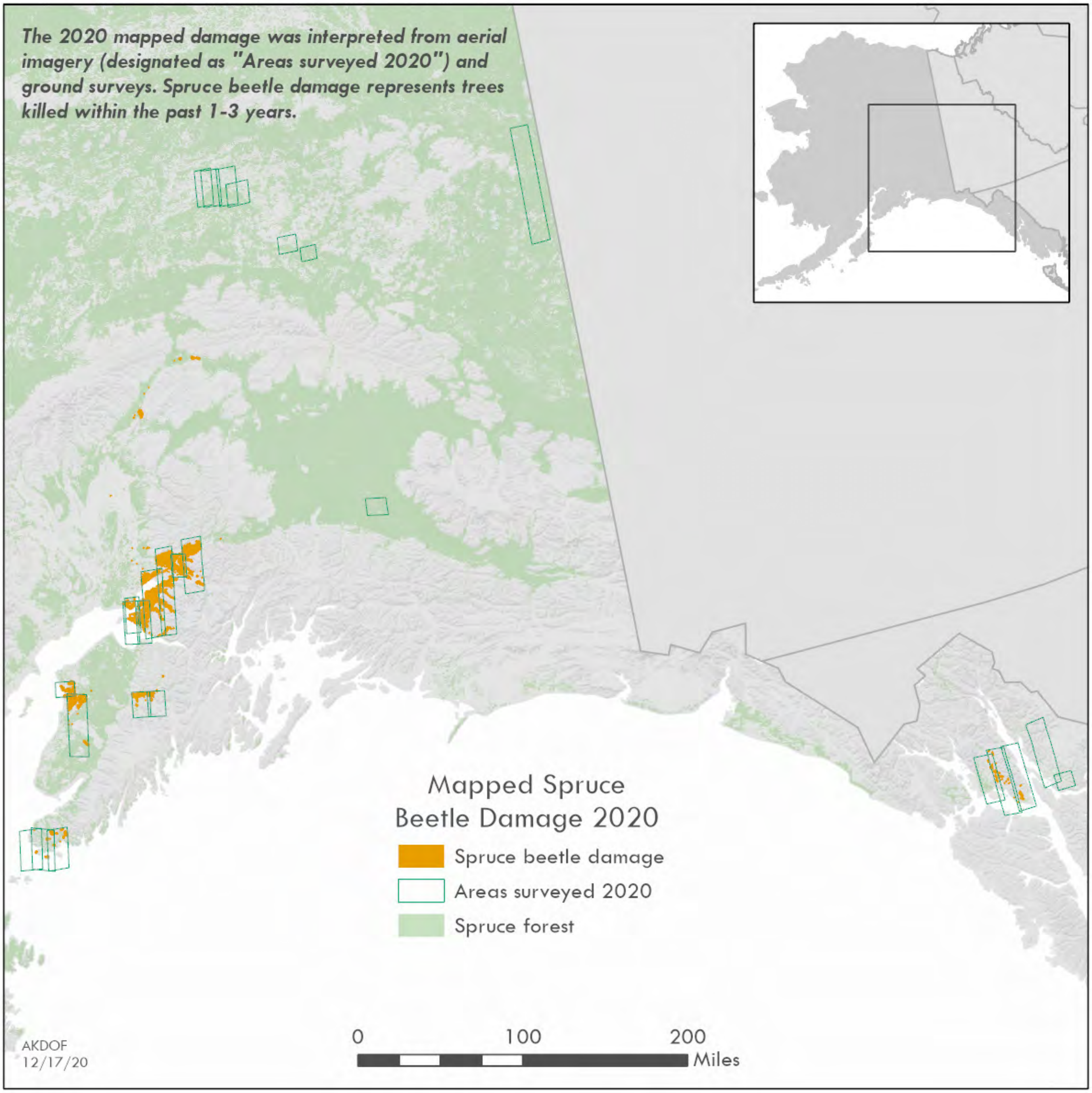
Ground surveyors observed close to 6,000 acres with ongoing spruce beetle-caused mortality. The acres mapped in 2020 within each of the affected boroughs is as follows (in descending order, rounded):

- Matanuska-Susitna: 4,000 acres
- Denali: 1,200 acres
- Kenai Peninsula: 450 acres
- Anchorage Municipality: 280 acres

Imagery Interpretation

High-resolution imagery acquisition for the entire area of the outbreak was not possible, so areas thought to be within the leading edges of the spruce beetle outbreak were prioritized for download. This resulted in limited coverage of the outbreak overall, but higher-level focus on areas where the outbreak was known to be active or expanding. The outlines of the imagery coverage areas are included on the maps in this section. In addition to spruce beetle damage mapped within the outbreak area, spruce beetle damage was also mapped from images in locations outside of the Southcentral outbreak area and during ground surveys.

This survey methodology essentially allowed for complete coverage of areas within each image and also allowed for a more complete survey of areas not typically well-covered during aerial surveys, specifically the Anchorage Municipality. The data collected in 2020 mark the most comprehensive assessment of the spruce beetle outbreak activity conducted by Region 10 FHP and DOF within the Municipality. Additionally, surveying the images in this way allowed for coverage of areas impacted within the outbreak that may not have been previously flown, such as narrow valleys or areas obscured by weather during past aerial surveys. In many cases, image quality made it difficult to discern between active spruce beetle damage, the typical goal of aerial surveys, and trees that may have died in 2018 or 2019. Distinguishing active damage from the previous year's damage is much more easily determined during aerial surveys. With this opportunity for complete coverage and the complication of accurate assessment of current damage, surveyors agreed to map all visible spruce beetle damage. Surveyors agreed to identify damage that appeared current or nearly so as *current mortality* (<2 years old) and damage that could be identified as spruce beetle-caused mortality but that was clearly older than two or three years as *mortality, previously undocumented*.



Map 31. All spruce beetle damage mapped statewide during imagery interpretation and ground surveys in 2020. Damage represents trees that were killed within the last 1-3 years.

INSECTS

All acreages outlined below should be considered *current mortality* unless otherwise noted. While important in tracking the overall geographic extent of the outbreak, the acres of older, previously undocumented spruce beetle activity are excluded from the remaining acreage calculations in this section.

In total, roughly 115,000 acres of spruce beetle activity were documented through high-resolution imagery interpretation in 2020, of which 108,000 acres were considered to be recent mortality. Of the recent damage mapped, 96% is within the outbreak area in Southcentral Alaska. Over 97,000 acres of the recent activity were in white spruce, 6,500 acres in black spruce, and 4,000 acres in Sitka spruce. Surveyed areas experiencing notable spruce beetle activity in 2020 are listed below.

Southcentral – Matanuska-Susitna and Kenai Peninsula Boroughs, Municipality of Anchorage :

These boroughs, with the addition of the southern Denali Borough, encompass the largest portion of the ongoing spruce beetle outbreak (Map 32). Images processed covered portions of the southeastern Matanuska-Susitna Borough, much of the Municipality of Anchorage, and locations on the western Kenai Peninsula; no imagery was processed for the Denali Borough.

Matanuska-Susitna Borough (60,130 acres)

The spruce beetle outbreak appears to have expanded considerably in the Matanuska River Valley from the confluence with the Knik River upriver to at least Thirtymile Lake. Additional extensive damage was documented extending west from the Matanuska River along the southern edge of the Talkeetna Mountains, primarily north of the Little Susitna River, with pockets of recent spruce beetle damage scattered across the Wasilla and Meadow Lakes areas. Large pockets of recent spruce beetle damage were also documented along the Knik River near the Knik Glacier; this damage extended into the Municipality of Anchorage as well.

Municipality of Anchorage (25,760 acres)

With survey coverage in Anchorage typically limited, many of the spruce beetle-impacted forests observed included a mix of recently killed trees and those that had been killed earlier in the outbreak. This survey effort also confirmed that the impacts of the outbreak on the Municipality were much more extensive than previously known.

The outbreak appears to be most severe in the portions of the Municipality from Joint Base Elmendorf-Richardson north to the Knik River, including all the major valleys in the Chugach Mountains south to the Ship Creek valley. Nearly all areas of the Anchorage Bowl are experiencing some level of spruce beetle activity. Recent spruce beetle activity was documented along many of the major creeks and some larger and more concentrated areas of damage were observed in east Anchorage, notably in Far North Bicentennial Park and the Campbell Tract, as well as in Kincaid Park in west Anchorage. Many pockets of recent spruce beetle activity were also observed in the Bird Creek valley along Turnagain Arm. Spruce beetle activity in this valley was unknown to surveyors prior to this survey effort and will be investigated in 2021.

Kenai Peninsula Borough (18,330 acres)

Two main areas on the Kenai Peninsula were prioritized for assessment of the spruce beetle outbreak, the Cooper Landing area and the Kenai/Soldotna area. Due to the images obtained to cover these areas, a swath from Soldotna south to the Caribou Hills was surveyed. While there were targeted coverage areas for spruce beetle, in all regions additional images were obtained and processed as time allowed. On the Kenai Peninsula, additional images covering the southwestern tip of the peninsula and the Chugach Islands were processed as well.

Spruce beetle activity increased substantially in the Cooper Landing area in 2020, with pockets of damage observed along the Sterling highway and Kenai River from roughly Quartz Creek campground west nearly to Skilak Lake road; coverage farther west was limited by the image boundary. Spruce beetle-caused mortality was also scattered along the Russian River several miles upstream from its confluence with the Kenai River.

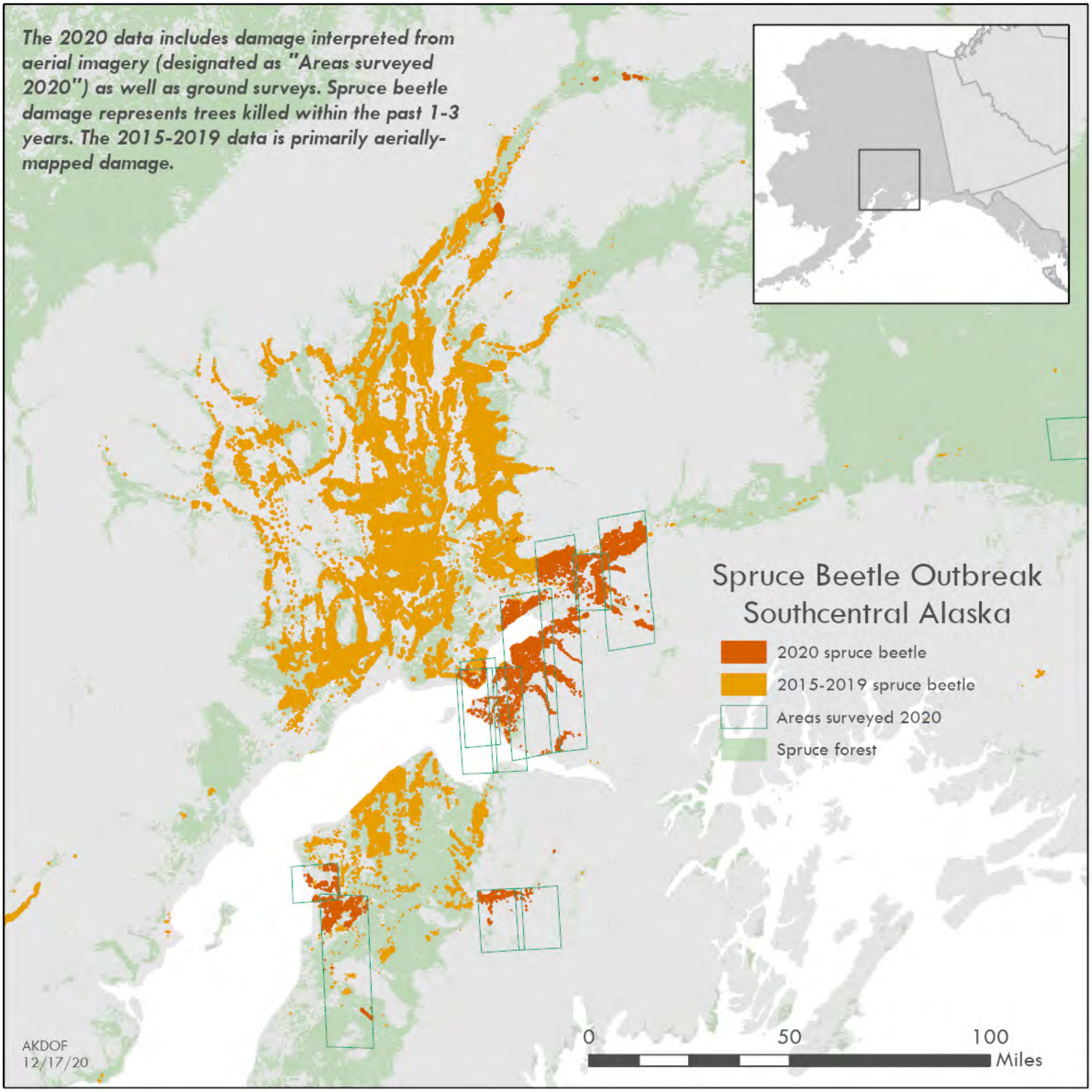
Spruce beetle activity continued to expand in the Kenai and Soldotna areas, with activity continuing in the Kenai National Wildlife Refuge as well as in the vicinity of the Kenai Spur highway from Soldotna to Kenai and west slightly farther than the airport. The damage appears equivalently extensive in the Soldotna vicinity, especially on the south side of the Kenai River, and continuing south nearly to Kasilof. An additional area of recent damage was observed south of Tustumena Lake in the Caribou Hills. On the southwestern tip of the Peninsula, recent spruce beetle activity was observed in Sitka spruce along Port Dick Creek, the Rocky River, and around Seldovia Lake; some damage was also mapped on Perl and Elizabeth Islands.

Southeast (121 acres)

Small scattered pockets of spruce beetle activity continue to be observed around Excursion Inlet and along the Excursion River, along with older previously unmapped spruce beetle-caused mortality. Both the Excursion River valley and the nearby Endicott River valley have had scattered spruce beetle activity documented in recent years, however the imagery obtained for the 2020 surveys did not cover the Endicott River valley.

Northern Spruce Engraver
Ips perturbatus (Eichhoff)

No notable areas of northern spruce engraver damage were observed during the 2020 ground surveys or imagery interpretation efforts. Damage from northern spruce engraver is typically mapped along streams and rivers and in areas with natural disturbances such as fire and wind.



Map 32. Spruce beetle damage mapped in Southcentral Alaska during imagery interpretation and ground surveys in 2020. 2015-2019 data reflects damaged mapped during aerial detection surveys.

Urban Pests

Dendroctonus rufipennis (Kirby)
Adelges piceae (Ratzeburg)
Pineus coloradensis (Gillette)

Spruce beetle (*D. rufipennis*) continues to be a top damage causing agent in urban and community trees in Southcentral Alaska and particularly in Anchorage (Figure 68). Requests for identification, general information, and information regarding removal and processing of spruce beetle infested material continue to be high.

Balsam woolly adelgid (*A. piceae*) was found infesting ornamental true fir in Juneau, AK in 2019, the vast majority of which were in Dimond Park. The City and Borough of Juneau moved quickly to remove all 36 true fir on city property and destroy the infested material (Figure 69). Several infested trees remain on private properties in Juneau. The Alaska Division of Forestry is developing a cost-share program to assist Juneau home and business owners with removal of infested trees.

In 2020, the University of Fairbanks Cooperative Extension service and the Alaska Division of Forestry investigated a report of suspected woolly adelgids on several long-established lodgepole pines in the Big Lake area. Since lodgepole pine are not native to the region, these adelgids are of particular interest. During a site visit, specimens were collected from infested trees and sent to a specialist for DNA-based identification. The species was confirmed as *Pineus coloradensis.* The adelgids were most prevalent on numerous potted lodgepole pine seedlings described by the landowner as being the natural regeneration of several long-established larger lodgepole pines. It is unclear whether this adelgid species occurs naturally in the state or if it may have been introduced. Further investigation is needed.

Figure 69. A City and Borough of Juneau crew works to destroy fir trees infested with balsam woolly adelgid, an invasive pest discovered in Juneau in 2019. USDA Forest Service photo.

Figure 68. Spruce trees along a trail in Anchorage show signs of foliar color change as a result of spruce beetle infestation. Courtesy photo by UAF-CES.

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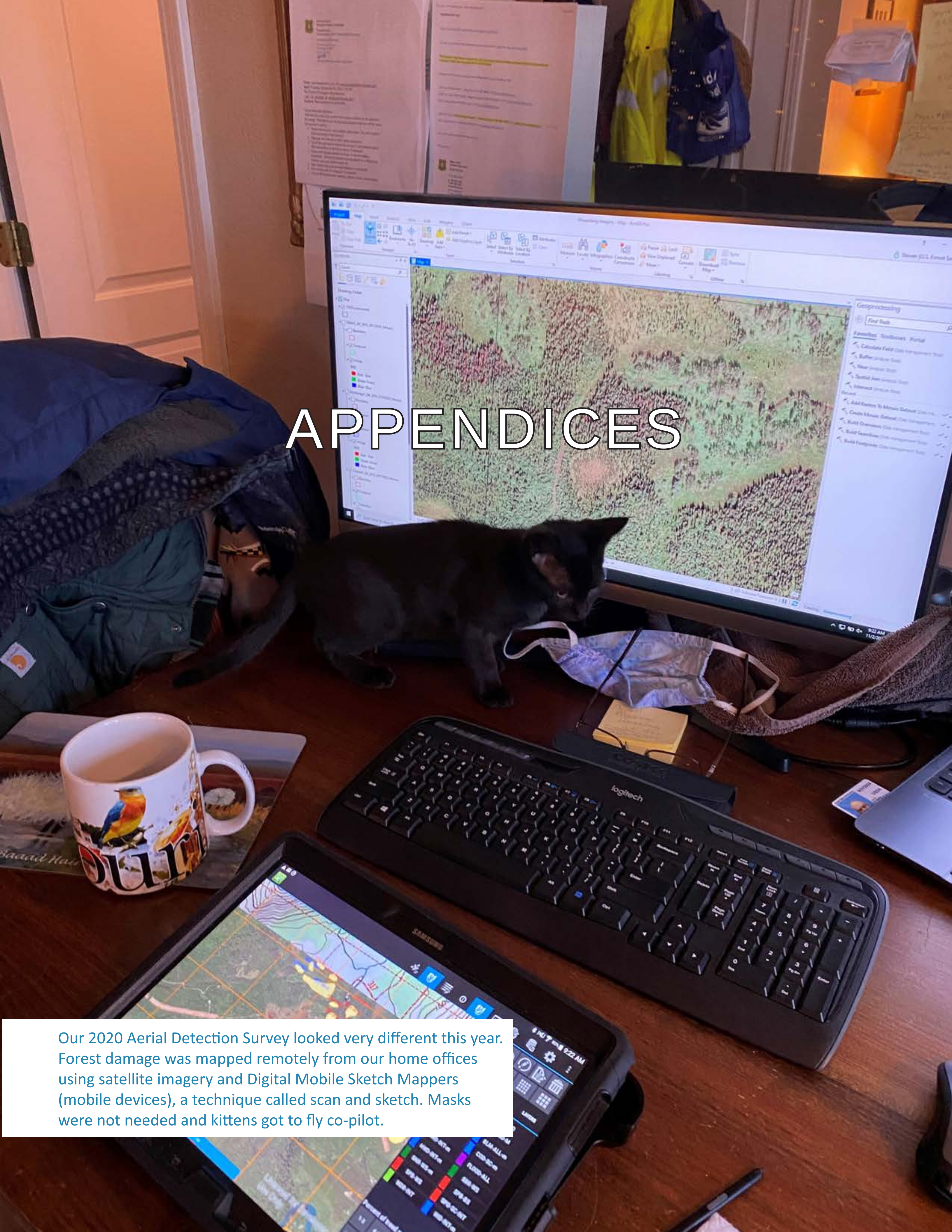
APPENDICES



Our 2020 Aerial Detection Survey looked very different this year. Forest damage was mapped remotely from our home offices using satellite imagery and Digital Mobile Sketch Mappers (mobile devices), a technique called scan and sketch. Masks were not needed and kittens got to fly co-pilot.

Appendix I: Aerial Detection Survey

This year proved challenging for forest health work as a result of the COVID-19 pandemic. Substantial time and effort was devoted to developing mitigations and alternate survey methods to collect the information needed to assess the health of Alaska's forests. Due to the uncertainty and concern surrounding the COVID-19 pandemic and the methods of mitigating risk during aerial survey operations, the 2020 R10 cooperative aerial detection survey (ADS) missions conducted jointly by Forest Service, State and Private Forestry, Forest Health Protection (FHP), and Alaska Department of Natural Resources, Division of Forestry (DOF) were cancelled. Trapping efforts were reduced and conducted only in areas of greatest concern, while ground surveys were expanded to get a better understanding of what was happening along the road and trail systems.

As COVID-19 cases continued to increase in Alaska in the spring of 2020, the level of comfort surrounding ADS decreased due to the risks associated with survey staff potentially contracting the disease, the potential for asymptomatic staff or pilots to spread COVID-19 into small, remote communities, the potential for putting additional strain on overwhelmed emergency response and medical teams should a mishap occur, and delays in ADS logistical planning decreased confidence in mission readiness. The pandemic also resulted in new layers of COVID-19 mitigations and precautions added to an already robust list of aviation safety precautions involved in normal ADS operations. It was felt that the combination of all standard and new mitigations and precautions may actually compound the risk involved in these missions.

In June of 2020, members of the FHP/DOF survey team developed an alternate plan in lieu of ADS and normal field operations. Documentation of the ongoing spruce beetle outbreak in Southcentral, and hemlock sawfly damage in Southeast were a priority for both FHP and DOF. To address these and other agents, a plan was developed to: (1) utilize satellite-based remote sensing imagery and tools to assess landscape wide damages, (2) implement an Aerial Detection-Replacement Survey, and (3) use casual and stakeholder observations to promote further investigation.

1. *Remote Sensing Options*

Landsat-based change detection methods, notably LandTrender, can be used to detect a persistent slow decline in forest health, as well as severe damage events. Unfortunately, this moderate-resolution method is less capable of detecting light, scattered, or ephemeral disturbances and is also unable to provide enough detail to identify causal agents. Higher-resolution imagery could help by informing and confirming Landsat change data. Areas of Interest (AOI) were identified and high-resolution imagery was requested in Southcentral (Figure 70) and Southeast Alaska (Figure 71) to monitor high priority damage agents. These high-resolution images were processed into ArcGIS Tile Package (TPK) files and visually assessed during "scan and sketch" surveys, which is described in detail below. In the future it is our hope that these tools and methods of change detection will be used in conjunction with ADS and ground surveys to provide a more complete picture of forest health in Alaska.

While moderate-resolution imagery (Landsat and Sentinel-2) and some high-resolution imagery (< 1 m resolution) is free, high-resolution imagery might also need to be purchased. Regardless of acquisition method, there are obstacles to procuring useful imagery within a required temporal window. We chose to request no-cost high-resolution imagery available through an existing federal agreement. Some was ordered with our specific requirements while most was chosen from imagery collected for previous requestors that was made available to other users. Many of our options were thus limited to the date range and specific coverage areas determined by the original requestor. When requesting or searching for imagery, a date range of June through September was preferred, depending on the agent and area of interest. This date range covered our normal July ADS while also taking into consideration early- and late-season damage causing agents active outside our normal ADS window.

Free high-resolution imagery was found to be available in limited areas. Areas of interest predetermined by FHP and DOF were only marginally covered, which was unfortunate but unavoidable. Weather and atmospheric conditions were limiting factors as was the acquisition of imagery by other agencies for wildfire management and suppression elsewhere in the country taking precedent. However, there was a substantial amount of imagery outside of our AOIs requested by other agencies that met our usage requirements (Figure 70 and Figure 71).

The scan and sketch survey process, which was specifically developed in 2020 to help maintain survey efforts during the pandemic, involves loading TPK files (Figure 72) of high-resolution imagery onto the Digital Mobile Sketch Mapping (DMSM) tablets used during normal ADS operations. With this high-resolution imagery as the base map, the surveyors manually scroll across the image while visually scanning for forest damage signatures. Surveyors can then circle damage areas (Figure 73) and attribute them with the proper damage causing agents in the same manner as they would during surveys conducted aerially. This data is then synced to the Forest Health Assessment & Applied Sciences Team (FHAAST) server as is done with normal ADS data. The scan and sketch survey process is similar to traditional ADS though there are strengths and weaknesses associated with both methods. During ADS, surveyors can diverge from planned flight lines and investigate damage as needed, as well as review the placement and damage aspects of polygons by comparing the view outside the plane with that on the DMSM. ADS also provides surveyors with a landscape view at 1,000 to 1,500 feet above ground level, where damage causing agents and host tree species are more easily discernable. However, forward movement is constant and decisions must be made quickly without the luxury of closer scrutiny aside from occasionally circling back and landing were possible. There are also inherent aviation risks involved in ADS operations and survey coverage is limited to a subset of the forested lands in the state each year. With scan and sketch survey, surveyors may safely inspect a large area with 100% coverage at their leisure in the office regardless of weather conditions, allowing for unlimited scrutiny and discussion. However, this method is more time-intensive and no-cost imagery is not always available for a particular AOI or during an ideal acquisition date range and agents and hosts are often difficult to discern in an image. Additionally, images are collected under variable conditions and over varying dates, which can lead to dramatic differences between the images in sharpness, colors, clouds, and other factors that influence the ease with which they can be interpreted.

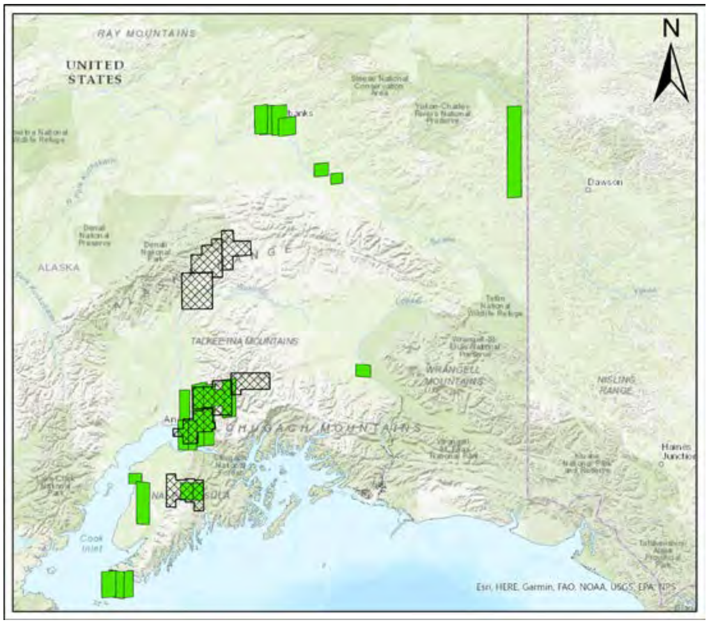


Figure 70. Cross hatched areas show where high-resolution imagery was originally requested to assess spruce beetle damage in Southcentral. Green polygons show where imagery was able to be acquired for scan and sketch survey. Though some areas overlap, others did not. Acquired imagery did allow for the opportunity to survey for aspen leafminer and birch leafminer in the Interior.

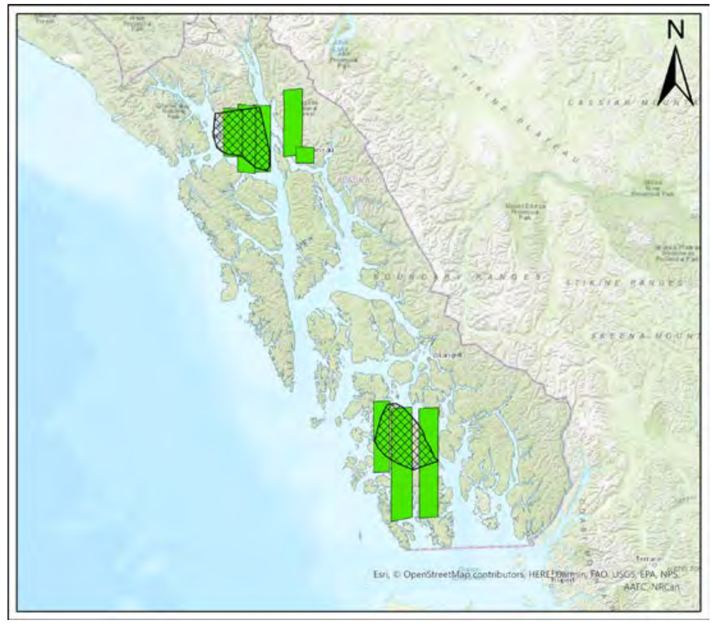


Figure 71. Cross hatched areas show where high-resolution imagery was originally requested to assess hemlock sawfly damage in Southeast. Green polygons show where imagery was able to be acquired for scan and sketch survey. There was more overlap between requested and acquired imagery in Southeast.

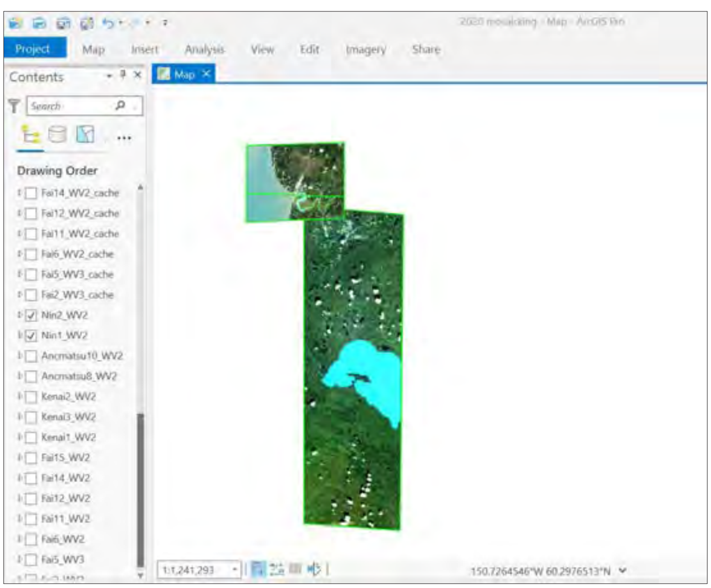


Figure 72. Raw imagery files that have been processed into ArcGIS Tile Package (TPK) files that will be loaded onto the DMSM for use during scan and sketch survey.

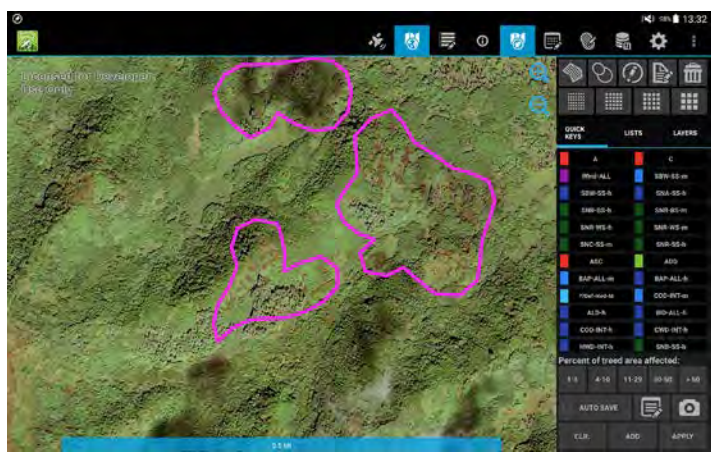


Figure 73. ArcGIS Tile Package (TPK) files are seen loaded onto the DMSM and ready for scan and sketch survey. Shown are areas of alder dieback that were easily visible using the TPK on the DMSM.

Imagery Acquisition

Three sources of free imagery were identified early in the planning process:

1. High-resolution Worldview 2 and Worldview 3 imagery was searched and requested through Digital Globe (discover.digitalglobe.com; https://evwhs.digitalglobe.com/myDigitalGlobe/login) and from the USGS using their CIDR[1] imagery request tool (https://cidr.cr.usgs.gov/). Using these sites, federal agencies are licensed to search available imagery or request that imagery be acquired for a specific AOI within a specific date range. These acquired images can then be shared internally with cooperators or collaborators to be used on federal projects only. Both sources of imagery were used extensively in 2020.

2. Moderate-resolution Landsat imagery can be used to detect slow decline and severe damage events state-wide. Persistent cloud cover in the summer of 2020 made broadscale detection of forest change challenging. Methods continue to be developed and tested.

3. Forest Service and the Alaska Mapping Executive Committee (AMEC) contracted to obtain high-resolution imagery for >50% of Alaska in 2020. Since there was no estimated timeframe for its acquisition, processing, and availability, it was not used while assessing forest damage in the 2020 season. It is thought that it may be available in early 2021 and FHP could be used to help inform decisions about AOIs for the 2021 survey season.

FHP purchased and began method development for an aircraft-mounted high-definition Global Navigation Satellite Systerm (GNSS)/GPS-enabled video camera to record oblique video of the forests. A pilot could mount the camera on their plane and record video on specific flights or opportunistically for FHP and DOF. Once recorded, the spatially-referenced full motion video would be processed and assessed in the office. This methodology was not applied in 2020 but will be tested further in 2021.

[1]CIDR is the acronym for Commercial Remote Sensing Space Policy (CRSSP) Imagery-Derived Requirements

Imagery Processing Support from GTAC

Throughout the 2020 survey year, the Forest Service Geospatial Technology and Applications Center (GTAC) provided an enormous amount of technical support in the form of webinars, reoccurring virtual meetings, and thorough user guides to facilitate efficient and timely image acquisition and processing. The steps to identify, order, and process imagery into a suitable format for scan and sketch survey sometimes took days to weeks due to the massive size of files and slow transfer and processing times. Much of the process has now been streamlined and will continue to improve in the future.

2. ADS/Remote Sensing Support Ground Survey

To augment the use of high- and moderate-resolution imagery, and to inform mapping decisions during scan and sketch survey, ground surveys were conducted along the road and some trail systems of Interior, Southcentral, and Southeast Alaska. Surveys started in mid-June and continued until mid-October depending on location and seasonal conditions. Ground data were recorded using an FHP-created survey form in ArcGIS Survey123 (Figure 74). This survey has been used by FHP to record and report ground observations in recent years but was updated to (1) allow for the collection of data relevant to ADS/remote sensing needs, (2) make data available for use in FHP annual ground observational reports, and (3) make it easier to report the new forest health data to FHAAST. Additional data were also collected during these ground surveys using the DMSM.

Survey routes were prioritized by regional staff considering past damage and designated AOIs (Figure 75, and 76 on page 70). When possible, ground surveys were planned within accessible scan and sketch survey AOIs to validate damage assessments derived from the remotely-sensed imagery and to refine future procedures and protocols. Ground surveys consisted of day and overnight trips of at least two crew members for which COVID-19 risk assessments were conducted and mitigations adhered to.

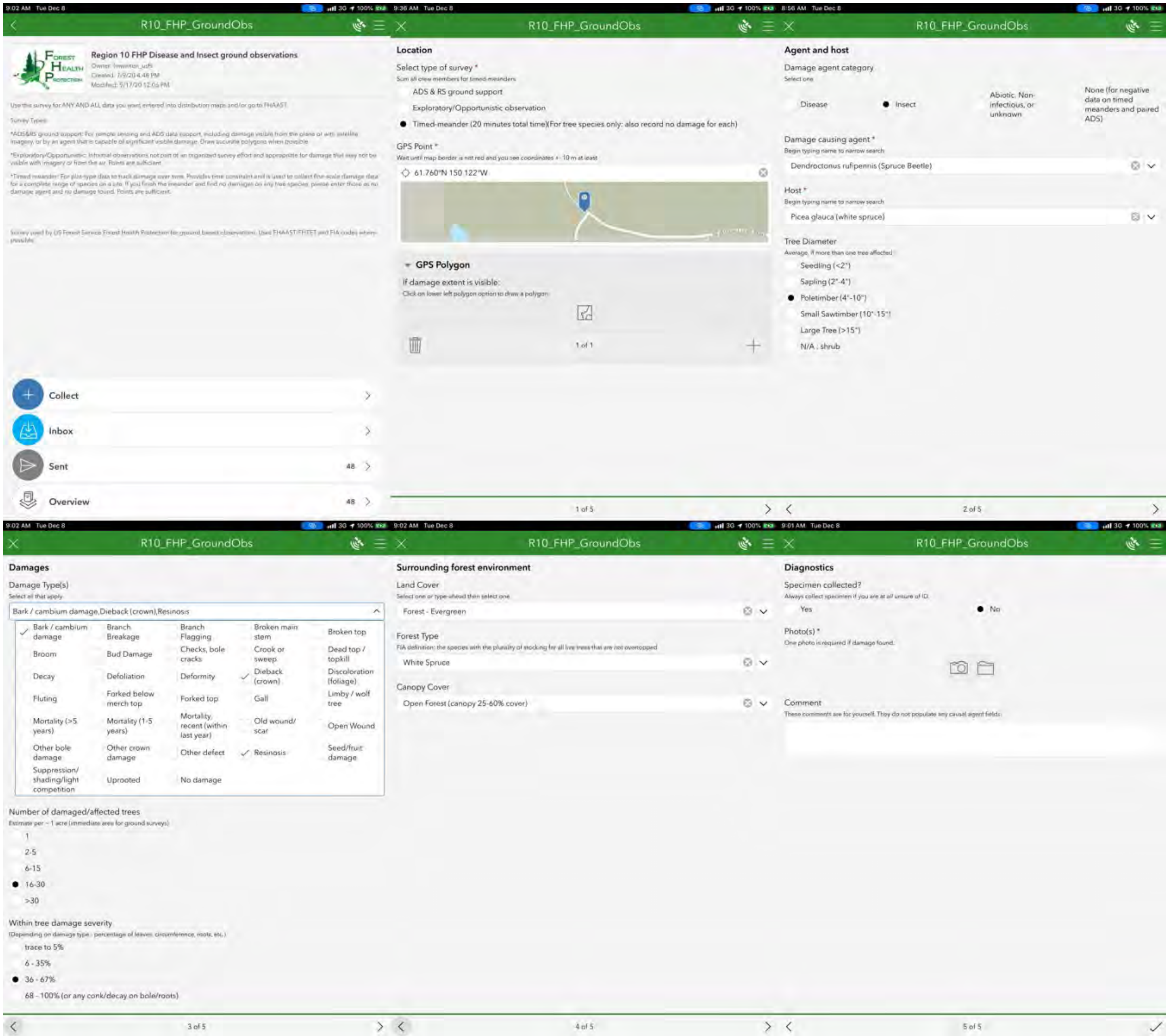


Figure 74. Ground data were recorded using an FHP-created mobile phone survey in ArcGIS Survey123, displayed here as a series of six mobile phone screenshots. The existing R10 FHP Ground Observations survey was adapted to also allow for the collection of ADS/RS data that could help to inform remote sensing processes.

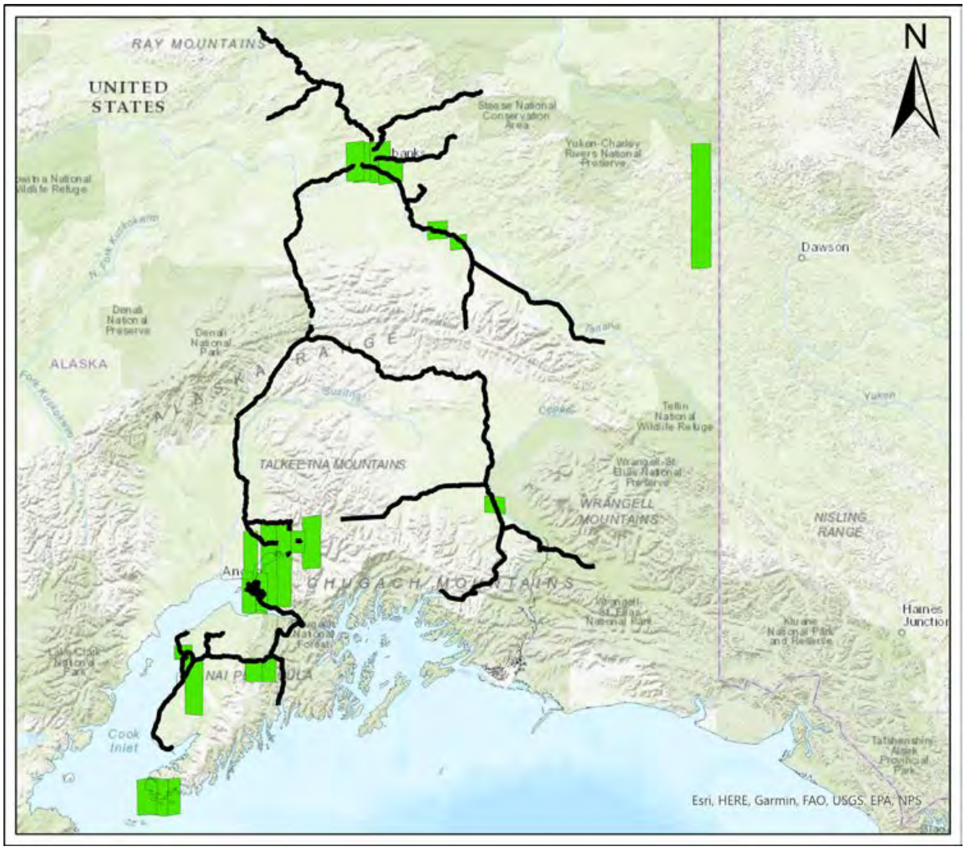


Figure 75. Ground survey routes (black lines) and AOIs (green polygons) in the Interior and Southcentral overlapped whenever possible.

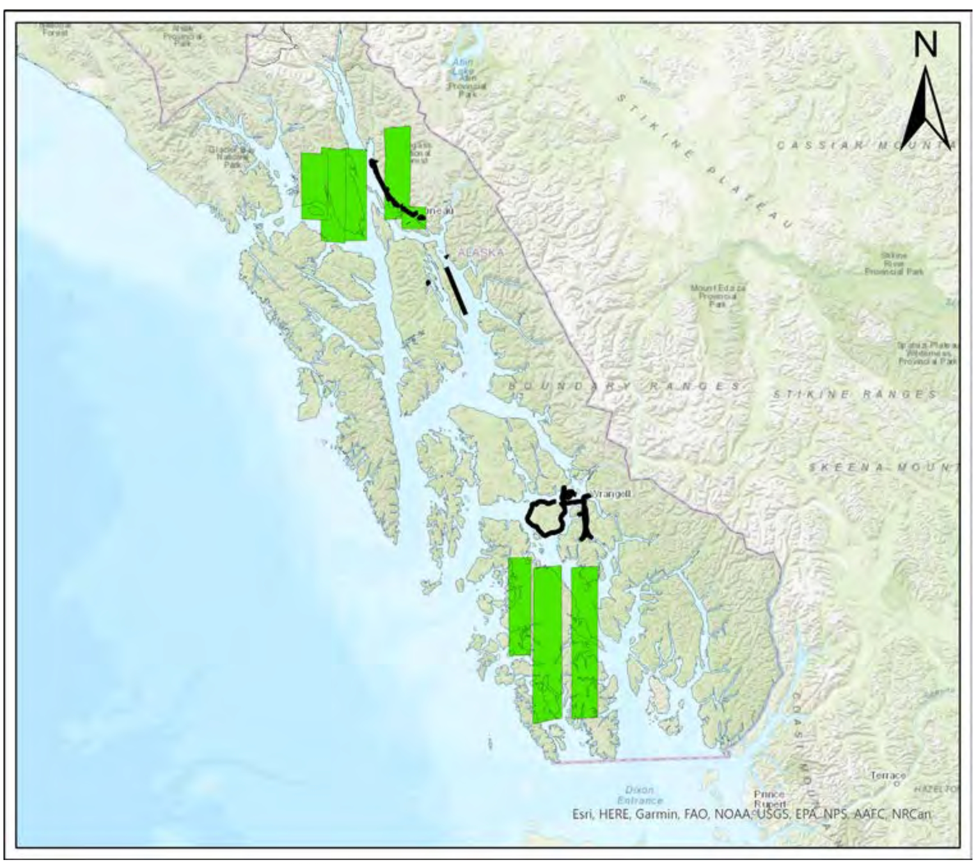


Figure 76. Ground survey routes (black lines) and AOIs (green polygons) in the Southeast overlapped whenever possible.

3. Other Eyes in the Sky and on the Ground

Pilot, cooperator, and public reports of damage were incredibly valuable in 2020. Because of our pandemic-limited field operations, these reports informed us of forest damage in areas we may have otherwise not seen. Reported large areas of notable damage gave us indications of where we could use the imagery to test and refine methods and alerted us to sites where we should conduct ground visits. These reports and our subsequent follow-up visits helped to give us a more complete picture of Alaska's forest health in 2020.

4. Summary of Results

In an average year, approximately 28 million acres of Alaska are surveyed and 900,000 acres of damage are recorded. In 2020, about 4.8 million acres were surveyed using the scan and sketch survey method with over 375,000 acres of damage recorded. Acres mapped during scan and sketch survey are valuable for assessing forest health, though they are difficult to directly compare to previous years' data as the methods differ significantly from traditional ADS. In addition to the acres surveyed during the scan and sketch survey, another 2.5 million acres were represented in the area covered in the ground survey. During ground survey, specific points were surveyed along some trails and the road system. Most ground survey records include site, occurrence, and damage severity, but not acreages. However, if the damage observed along roads and trails was substantial enough to be potentially observed during traditional ADS, then this damage was recorded as polygons either using the DMSM or the Survey123 ground survey application, a survey practice that we dubbed as "Aerial Detection-Replacement Survey." Those polygons and acreages were included in the damage totals for their respective collection method. Because the areas of interest were chosen specifically for just a few agents of concern, the suite of damage causing agents recorded with scan and sketch survey was greatly reduced from typical ADS. Fortunately, many that could not be seen during scan and sketch survey were recorded during ground surveys. Listed below are the major damage-causing agents mapped with the scan and sketch survey method in 2020, as well as a few others to consider. A more in-depth reporting of the agents is detailed in the Status of Insects section, starting on page 51.

Aspen Leafminer

Approximately 39,000 acres of aspen leafminer were mapped using scan and sketch survey. Although easily visible in high-resolution imagery, acres mapped were down considerably from the previous 5-year average of 162,000 acres. The reduction in acres mapped is understandable when considering that 4.8 million acres were surveyed using scan and sketch survey as opposed to the average of 28 million acres surveyed with ADS. Something else to consider in regard to acres mapped is that much of the imagery acquired was chosen to address spruce beetle activity and to some degree, hemlock sawfly activity. In choosing AOIs for a particular pest, geographic and temporal requirements can limit the number of other damage agents may be encountered.

Hemlock Sawfly

Hemlock sawfly damage areas were prioritized in Southeast wherever high-resolution imagery could be acquired within the preferred temporal window. With suitable imagery, hemlock sawfly proved to be somewhat straightforward to identify, with over 143,000 acres mapped during scan and sketch survey. However, it was sometimes difficult to tell whether topkill and other partial defoliation would lead to mortality. While the number of damage acres in 2020 is similar to 2019, they are not easily compared and are concentrated in a more thoroughly surveyed AOI as opposed to being spread over a much broader landscape as with typical ADS. Due to severe and contiguous defoliation of hemlock trees, hemlock sawfly damage was easily detected with moderate resolution Landsat imagery and LandTrendr methods, but only for areas with cloud-free imagery. In 2019, we had some success with sufficient cloud-free imagery that allowed us to measure the damage extent, but in 2020 a persistent cloud cover interfered with a complete assessment. For more information on the current hemlock sawfly outbreak, please refer to the essay on page 14.

Spruce Beetle

The ongoing spruce beetle outbreak is still a major concern and was the focus of Southcentral scan and sketch survey operations. High-resolution imagery was available for many AOIs within the Municipality of Anchorage, Matanuska-Susitna Borough, and the Kenai Peninsula. In these areas, surveyors mapped over 145,000 acres of spruce beetle damage in 2020, which is slightly less than the ADS spruce beetle acres mapped in 2019. However, direct comparison to previous years' data is not easy to make and damage was concentrated in more thoroughly surveyed AOIs as opposed to being spread over a much broader landscape as with typical ADS. Also, although damage is easily detected during scan and sketch survey operations, occasionally there can be some difficulty in differentiating current season damage from one- to two-year-old damage. Scrutiny is required while scanning, adding to the time needed to complete the process.

Other Agents to Consider

Birch Leafminers

Birch leafminers have been in outbreak for several years in the Anchorage and Wasilla areas as well as in and around Fairbanks. This damage is easily observed on the ground from trace to heavy levels but is usually not severe enough to map in significant numbers during ADS until early- to mid-August. In 2018, late season spruce beetle flights were flown in Southcentral during which surveyors confirmed that birch leafminer damage (*Profenusa thompsoni* and *Heterarthrus nemoratus*) was in fact more observable than during the typical mid-July survey when most other damage agents in Alaska are visible. It was decided that the mid-August flights would continue and the temporal change has resulted in a substantial increase in birch leafminer acres mapped, even though ground surveys showed there was not a substantial increase in birch leafminer activity.

During our scan and sketch survey operations of 2020, only 2,800 acres of birch leafminer were recorded, a considerable drop from 2018 and 2019. However, through ground surveys we were able to record that birch leafminer damage spread to new areas in the Interior and to a lessor extent in Southcentral. Many of the areas within the AOIs that were known to have birch leafminer identified during ground surveys had damage that was undetectable in the imagery. This was partially due to timing of the imagery and due to a decrease in the amount of birch leafminer damage in Southcentral.

Birch Aphid

There were several known areas of heavy birch aphid defoliation in the Interior, some of which were covered by high-resolution imagery, that were not noticeable during scan and sketch survey. Two hundred and twenty-four acres of birch defoliation associated with birch aphid were mapped using the DMSM during ground surveys along Johnson Road in Salcha that were not covered by imagery, though others positioned along the Richardson Highway near Birch Lake were well within the imagery. One particular polygon was mapped around the edges of a borrow pit off of the Richardson Highway. This pit was visited multiple times over the season where birch aphid caused near-complete defoliation of the birch around the pit. The damage was recorded in ground surveys and mapped as such but not recognizable in imagery. The timing of the image acquisition was good, but the quality of that particular image may have been inadequate. Damage could have also been masked by some of the birch that partially re-foliated or by the other tree and shrub species present in the understory that were not defoliated.

Willow Leafblotch Miners

Ground observations demonstrate that, like aspen leafminer, willow leafblotch miner is always present throughout the Interior and is more widespread than aerial surveys indicate. This is possibly due to the timing of ADS and damage severity during survey operations. In 2020, only a fraction of typical willow leafblotch miner damage was mapped. There is no doubt that willow leafblotch miner is spread across the Interior landscape and even parts of Southcentral, this was quite evident from ground surveys. Willow leafblotch miner was also visible in many locations while traveling between survey points, along every Interior road, as well as a few sites in the Copper River Valley. Although it is known to be widespread, little damage was observable in the acquired imagery, likely due to image quality or timing of image acquisition.

5. Conclusions

At present, it is not advisable to replace ADS with other remote sensing methods. However, remote sensing and high- and moderate-resolution imagery will take on a greater role in forest health monitoring and detection going forward. We are also aware that more work will need to be done to refine methods and develop processes for stronger acreage comparisons and data analysis. After comparing methods, traditional ADS did have strengths that cannot be overlooked. As surveys and discussions are done in real time with agent activity and damage in front of you, there is the ability to adjust temporal and spatial variables within our flight minimums to optimize survey time and the ground truthing of floatplane-accessible remote locations is valuable in agent and damage identification. Deadlines for reporting forest health data have also been structured around the earlier availability of data gathered in a traditional ADS. These factors make ADS an invaluable tool, albeit with some drawbacks. Atmospheric conditions can delay or cause missions to be modified or cancelled, there is a safety risk that cannot be fully mitigated, and operational costs increase on an annual basis.

The use of high- and moderate-resolution imagery negates the risks involved with flight operations. In addition, scan and sketch survey will allow us to survey an image at our leisure, share imagery for second opinions and cover a larger area than with ADS. As we refine methods, remote sensing and high- and moderate-resolution imagery will help fill in some of the blanks that ADS cannot. Imagery for areas that cannot be flown or areas that were unable to be surveyed due to weather or smoke could possibly be acquired for scan and sketch survey. In conjunction with ADS and scan and sketch survey, moderate-resolution Landsat imagery can also be used to detect slow decline and severe damage events state-wide and be used to develop tools to produce predictive models. There are also temporal and financial factors to consider. Limitations to the use of high- or moderate-resolution imagery include unpredictable availability of images covering a particular AOI within a required temporal window, whether the quality of a particular image makes it useful, and the increased time and cost involved in acquisition, processing, and scanning.

Appendix II. Damage Type by Category

Abiotic
Flooding
Landslide/avalanche
Windthrow
Winter damage

Alder Defoliation
Alder defoliation
Alder leafroller
Alder sawfly

Alder Dieback
Alder dieback

Aspen Defoliation
Aspen defoliation
Aspen leaf blight
Aspen leafminer
Large aspen tortrix

Aspen Mortality
Aspen running canker

Birch Defoliation
Birch aphid
Birch defoliation
Birch leafminer
Birch leafroller
Dwarf birch defoliation
Spear-marked black moth

Cottonwood Defoliation
Cottonwood defoliation
Cottonwood leaf beetle
Cottonwood leafminer
Cottonwood leafroller

Fir Mortality
Western balsam bark beetle

Hardwood Defoliation
Hardwood defoliation
Speckled green fruitworm

Hemlock Defoliation
Hemlock looper
Hemlock sawfly

Hemlock Mortality
Hemlock canker
Hemlock mortality

Larch Defoliation
Larch budmoth
Larch sawfly

Larch Mortality
Larch beetle

Shore Pine Damage
Dothistroma needle blight
Shore pine dieback
Western gall rust

Spruce Damage
Spruce aphid
Spruce broom rust
Spruce bud moth
Spruce budworm
Spruce defoliation
Spruce needle cast
Spruce needle rust

Spruce Mortality
Northern spruce engraver
Spruce beetle

Spruce/Hemlock Defoliation
Black-headed budworm
Conifer defoliation

Willow Defoliation
Willow defoliation
Willow leafblotch miner
Willow rust

Willow Dieback
Willow dieback

Yellow-Cedar Decline
Yellow-cedar decline

Other damage (agent not identified)
Birch crown thinning
Hemlock flagging
Larch discoloration

Appendix III: Information Delivery

Internet and Social Media

Alaska Region Forest Health Protection: https://www.fs.usda.gov/main/r10/forest-grasslandhealth

Alaska Forest Health Conditions Reports, ADS Damage Maps and Story Maps: https://www.fs.usda.gov/detailfull/r10/forest-grasslandhealth/?cid=fsbdev2_038884&width=full

Forest Health Highlights 2020 Story Map: https://storymaps.arcgis.com/stories/5774a5b285b041ed9b773bfad0950471

Ground Survey Map Dashboard: https://arcg.is/1SH58a

Hemlock Sawfly in Alaska Video: https://www.youtube.com/watch?time_continue=1&v=Hhfz2_a39sQ

Spruce Beetle in Alaska's Forest (Interagency Site): https://www.alaskaprucebeetle.org/

Facebook: https://www.facebook.com/ChugachNF/, https://www.facebook.com/TongassNF/

Twitter: @AKForestService, @ChugachForestAK, @TongassNF, #AlaskaForestHealth, #AlaskaSpruceBeetle

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Charnon, B. C. 2020. Region 10 Invasive Species Program. Annual Silviculture and Wildlife Workshop. September 15. Virtual Presentation.

Charnon, B. C. 2020. US Forest Service, State and Private Forestry: Who We Are, What We Do and How We Can Help. Alaska Invasive Species Partnership Annual Conference. October 29. Virtual Presentation.

Graham, E.E. 2020. Ground survey to assess hemlock sawfly population during a large-scale outbreak in Southeast Alaska. Alaska Entomological Society Newsletter. Volume 13 Issue 1. http://www.akentsoc.org/doc/AKES_newsletter_2020_01.pdf.

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Graham, E. E. 2020. Hemlock Sawfly Outbreak. Alaska Region Forest Health Protection Technical Meeting. January 15. Juneau, AK.

Graham, E. E. 2020. What's Bugging the Hemlock? Mendenhall Glacier Visitor Center Fireside Lecture Series. March 20. Virtual Presentation.

Graham, E. E. and L. Winton. 2020. Insect and Disease Activity in Alaska. Local Environmental Observer Network. August 18. Webinar.

Graham, E. E. 2020 What's Bugging the Hemlock? Petersburg Rainforest Festival. September 11. Virtual Presentation

Hutten, K. 2020. Satellite-Based Change Detection. Aerial Survey Working Group Meeting. January 28-30. Portland, OR.

Hutten, K. 2020. Geospatial Solutions for Supporting ADS FY20 Field Season Webinar. May 27. Virtual Presentation.

Moan, M. J. 2020. Effects of climate change on insects. Chugach National Forest Climate Change Vulnerability and Adaptation Workshop. November 4. Virtual Presentation.

Mulvey, R. 2020. Website and Social Media Update. Alaska Region Forest Health Protection Technical Meeting. January 13-17. Juneau, AK.

Mulvey, R. 2020. Southeast Alaska Pathology Update. Alaska Region Forest Health Protection Technical Meeting. January 13-17. Juneau, AK.

Mulvey, R. and L. M. Winton. 2020. Region 10 Hazard Tree Program. Alaska Regional Leadership Team Meeting. February 26. Anchorage, AK. Content presented by M. Shephard.

Mulvey, R. 2020. Plant Disease and Disease Diagnosis for Master Gardeners. Cooperative Extension Service Master Gardeners Course. March 11. Virtual Presentation.

Mulvey, R. 2020. Forest Pathology in Alaska Update 2020. Forest Service, Region 10 Alaska Regional Silviculture and Wildlife Workshop. September 15. Virtual Presentation.

Winton, L. M. 2020. Forest Disease in Southcentral & Interior Alaska: Aspen Running Canker. Local Environmental Observer Network. August 18. Webinar. https://www.leonetwork.org/en/posts/show/17186C32-4E59-4BE6-BCE3-96C33D640937?cb=469e05aa-a004-42ab-9136-1ffd85ce9eb7

Winton, L. M. 2020. Forest Diseases in Alaska's Coastal Forests. Coastal Alaska Forest Inventory and Analysis. June 20. Virtual Presentation.

Winton, L. M. 2020. Climate Change and Forest Diseases. Chugach National Forest Climate Change Vulnerability and Adaptation Workshop. November 4. Virtual Presentation.

Winton, L. M. 2020. Southcentral & Interior Alaska Forest Fathology Update. Alaska Region Forest Health Protection Technical Meeting. January 13-17. Juneau, AK

Winton, L. M. 2020. Accessing FHP Data with the Operations Dashboard. Alaska Region Forest Health Protection Technical Meeting. January 13-17. Juneau, AK

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