Mt. Ashland Late-Successional Reserve
Habitat Restoration and Fuels Reduction Project
Cumulative Watershed Effects Analysis
Specialist Report

Cumulative Watershed Effects (CWE) Quantitative Models for
Surface Erosion, Mass-wasting and ERA/TOC

General:

Overlays of Forest GIS coverages were used to generate the tabular analysis that accompanies this process paper. Analysis area for quantitative model runs consists of thirteen (13) 7th-field drainages, twelve (12) 7th-field drainages that together comprise the Beaver Creek 5th-field watershed and one (1) 7th-field drainage (Headwaters Cottonwood Creek) from Cottonwood 5th-field watershed. See accompanying tables for a complete list of analyzed drainages. The proposed action lies within six (6) of these 7th-field drainages – Headwaters Cottonwood Creek, Beaver/Grouse Creek, Deer-Beaver Creek, Hungry Creek, Long John Creek, and Upper Cow Creek. Hungry Creek contains no treatment units, only part of unauthorized (unclassified or non-system) road 41S07.3 proposed to be opened, used, hydrologically stabilized then closed. While models runs were done on thirteen (13) 7th-field drainages and the Beaver Creek 5th-field watershed (collectively), CWE issues may exist at broader scales and must be discussed qualitatively. Broader scales include the Klamath River (mainstem) downstream of the project area. Typically quantitative analyses are done at the 5th-field scale in addition to 7th-field scale.

Ecosystem analysis at the watershed scale ("WAs") is completed for the analysis area, called *Beaver Creek Ecosystem Analysis* (USFS, 1996). This analysis updated 'Areas with Watershed Concerns' identified in the LRMP process. The Beaver Creek WA identified the following drainages as 'Areas with Watershed Concerns': (1) Long John, (2) Grouse Creek, and (3) Hungry Creek. The Westside CWE Analysis (USFS, 1998) and CWE 2004 – Cumulative Watershed Effects Analysis (USFS, 2004) generally supported these conclusions.

Beaver Creek watershed and its component drainages represent an area listed as needing development of a TMDL (Total Maximum Daily Load) under Section 303(d) of the Clean Water Act. These watersheds are listed for <u>nutrients</u> and <u>temperature</u> by virtue of being tributary to the Klamath River.

Streams in the analysis area flow directly into the Klamath River, which is designated and recommended as Wild, Scenic and Recreational rivers. 'Designated' river corridors are "final" LRMP approved; 'recommended' river corridors are preliminary until either Congress or the Secretary of the Interior designates these rivers. The Forest manages both designated and recommended rivers similarly.

CWE process described in this document is GIS based. Arc/Info coverages are therefore referenced in closed triangular brackets, <coverage>, for example. Results of this assessment are shown in tables (MS Excel worksheet) contained in the following files (MS Excel workbooks):
ALT2 cwe_sheds_ashland_17jul06.xl, ALT3 cwe_sheds_ashland_17jul06.xls, ALT4 cwe_sheds_ashland_17jul06.xls, ALT5 cwe_sheds_ashland_17jul06.xls, and *cwe_roads_ashland_17jul06.xls*. Key coefficients and important assumptions are found in *cwe_coefficients.xls* file. See below for more detailed discussion of the three models used in this assessment.

Summary of Findings:

Prior to implementation of the proposed action, the models (as shown in 'Current' section of spreadsheet *ALT 2,3,4,5 cwe_sheds_ashland_17jul06.xls*) indicate that of the thirteen (13) 7th-field drainages within the analysis area:

[1] Ten (10) drainages [all, except Headwaters Cottonwood Creek, Buckhorn-Beaver Creek and Upper Cow Creek] have elevated **USLE model** (surface erosion) values; six (6) have values greater than the USLE inference point (risk ratio greater than 1.0) – four (4) are approaching it (risk ratio between .80 and 1.0);

[2] Eight (8) drainages [Headwaters Cottonwood Creek, Beaver/Grouse Creek, Deer-Beaver Creek, Hungry Creek, Long John Creek, Lower West Fork Beaver Creek, Soda-Bumblebee and Upper West Fork Beaver Creek] have elevated **GEO model** (mass wasting) values; four (4) have value greater than the GEO inference point (risk ratio greater than 1.0) – four (4) are approaching it (risk ratio between .80 and 1.0);

[3] Five (5) drainages [Hungry Creek, Jaynes Canyon, Lower West Fork Beaver Creek, Soda-Bumblebee and Upper West Fork Beaver Creek] have elevated **ERA/TOC** values; three (3) have values greater than the TOC (risk ratio greater than 1.0) – two (2) are approaching it (risk ratio between .80 and 1.0).

Prior to implementation of the proposed action, Beaver Creek 5th-field watershed has elevated values for two of the three models: USLE = 1.17 and GEO = 0.91. After implementation of the proposed action, model values indicate watershed risk is slightly increased or decreased for the Beaver Creek 5th-field watershed; USLE (surface erosion) = **1.18** ('risk ratio'- slightly increased from prior to proposed action)**,** GEO (mass wasting) **= 0.90** ('risk ratio' – slightly decreased from prior to proposed action), and ERA/TOC **= 0.86** ('risk ratio' – slightly increased from prior to proposed action).

The Mt Ashland LSR project proposed action occurs lies within six (6) 7th-field drainages – Headwaters Cottonwood Creek, Beaver/Grouse Creek, Deer-Beaver Creek, Hungry Creek, Long John Creek, and Upper Cow Creek. After implementation of the proposed action, changes in model values are shown in the following tables.

The **USLE** model values for these drainages are as follows (**bold** denotes elevated values):

Alternative	7th-field Drainage	Current	After Project	With Future Actions
2	Headwaters Cottonwood Creek	.41	.42	.42
2	Beaver/Grouse Creek	**.94**	**.98**	**.98**
2	Deer-Beaver Creek	**.94**	**.96**	**.96**
2	Hungry Creek	**1.35**	**1.35**	**1.35**
2	Long John Creek	**.88**	**.97**	**.97**
2	Upper Cow Creek	.66	.67	.67
3	Headwaters Cottonwood Creek	.41	.42	.42
3	Beaver/Grouse Creek	**.94**	**.98**	**.98**
3	Deer-Beaver Creek	**.94**	**.95**	**.95**
3	Hungry Creek	**1.35**	**1.35**	**1.35**
3	Long John Creek	**.88**	**.95**	**.95**
3	Upper Cow Creek	.66	.66	.66
4	Headwaters Cottonwood Creek	.41	.42	.42
4	Beaver/Grouse Creek	**.94**	**.99**	**.99**
4	Deer-Beaver Creek	**.94**	**.96**	**.96**
4	Hungry Creek	**1.35**	**1.35**	**1.35**
4	Long John Creek	**.88**	**.97**	**.97**
4	Upper Cow Creek	.66	.67	.67
5	Headwaters Cottonwood Creek	.41	.42	.42
5	Beaver/Grouse Creek	**.94**	**.99**	**.99**
5	Deer-Beaver Creek	**.94**	**.95**	**.95**
5	Hungry Creek	**1.35**	**1.35**	**1.35**
5	Long John Creek	**.88**	**.96**	**.96**
5	Upper Cow Creek	.66	.66	.66

The **GEO** model values for these drainages are as follows (**bold** denotes elevated values):

Alternative	7th-field Drainage	Current	After Project	With Future Actions
2	Headwaters Cottonwood Creek	**.87**	**.87**	**.87**
2	Beaver/Grouse Creek	**1.50**	**1.48**	**1.48**
2	Deer-Beaver Creek	**.87**	**.87**	**.87**
2	Hungry Creek	**1.82**	**1.81**	**1.81**
2	Long John Creek	**1.45**	**1.39**	**1.39**
2	Upper Cow Creek	.50	.50	.50
3	Headwaters Cottonwood Creek	**.87**	**.87**	**.87**
3	Beaver/Grouse Creek	**1.50**	**1.48**	**1.48**
3	Deer-Beaver Creek	**.87**	**.87**	**.87**
3	Hungry Creek	**1.82**	**1.81**	**1.81**
3	Long John Creek	**1.45**	**1.39**	**1.39**
3	Upper Cow Creek	.50	.50	.50
4	Headwaters Cottonwood Creek	**.87**	**.87**	**.87**
4	Beaver/Grouse Creek	**1.50**	**1.49**	**1.49**
4	Deer-Beaver Creek	**.87**	**.87**	**.87**
4	Hungry Creek	**1.82**	**1.82**	**1.82**
4	Long John Creek	**1.45**	**1.41**	**1.41**
4	Upper Cow Creek	.50	.50	.50
5	Headwaters Cottonwood Creek	**.87**	**.87**	**.87**
5	Beaver/Grouse Creek	**1.50**	**1.49**	**1.49**
5	Deer-Beaver Creek	**.87**	**.87**	**.87**
5	Hungry Creek	**1.82**	**1.81**	**1.81**
5	Long John Creek	**1.45**	**1.39**	**1.39**
5	Upper Cow Creek	.50	.50	.50

The **ERA/TOC** model values for these drainages are as follows (**bold** denotes elevated values):

Alternative	7th-field Drainage	Current	After Project	With Future Actions
2	Headwaters Cottonwood Creek	.27	.33	.33
2	Beaver/Grouse Creek	.55	**.80**	**.80**
2	Deer-Beaver Creek	.71	**.83**	**.83**
2	Hungry Creek	**.80**	**.80**	**.80**
2	Long John Creek	.40	.76	.76
2	Upper Cow Creek	.32	.35	.35
3	Headwaters Cottonwood Creek	.27	.32	.32
3	Beaver/Grouse Creek	.55	.77	.77
3	Deer-Beaver Creek	.71	**.83**	**.83**
3	Hungry Creek	**.80**	**.80**	**.80**
3	Long John Creek	.40	.73	.73
3	Upper Cow Creek	.32	.34	.34
4	Headwaters Cottonwood Creek	.27	.33	.33
4	Beaver/Grouse Creek	.55	.77	.77
4	Deer-Beaver Creek	.71	**.83**	**.83**
4	Hungry Creek	**.80**	**.80**	**.80**
4	Long John Creek	.40	.70	.70
4	Upper Cow Creek	.32	.35	.35
5	Headwaters Cottonwood Creek	.27	.33	.33
5	Beaver/Grouse Creek	.55	.78	.78
5	Deer-Beaver Creek	.71	**.83**	**.83**
5	Hungry Creek	**.80**	**.80**	**.80**
5	Long John Creek	.40	.74	.74
5	Upper Cow Creek	.32	.35	.35

Information used in this assessment:

'Current [past & present]' section lists model output results from past and present activities. Information from many sources was combined. Past logging activities from Forest Service (FS) administered lands was obtained from the Forest's managed stands layer (<mgstands>). Managed stands layer was integrated with "recent" and "present" FS projects within the analysis area. See discussion below for more details ('Arc/Info coverages' section).

Harvest activities on private land were captured from DOQs (Digital Orthoquad) and recent THPs (Timber Harvest Plan). See Table A (*ALT 2,3,4,5 cwe_sheds_ashland_17jul06.xls*) for details. Thirteen (13) THPs were digitized and included for this project. They were: [1] Charles Lake THP (1998), [2] Wards Gap THP (1999), [3] Bull-Schneider THP (2000), [4] Jaynes Canyon THP (2000), [5] Beaver Creek THP (2001), [6] North Bear THP (2001), [7] Swayback THP (2001), [8] Hungry Parrot (2003), [9] Dead Cow THP (2004), [10] Deer Dog THP (2004), [11] Bear Trapper THP (2004), [12] Beaver THP (2004), [13] Sterling THP (2004) and [14] 1907 Summit THP (2005). The last four THPs were digitized as part of this project. These activities are shown in Table A as 'past and current private harvest' and XXX THP in 'Name' column. Some additional private roads were added from these THPs.

Effects from Crest, Beaver and Uptown proposed actions were not modeled, as these projects have been withdrawn. Modeled effects from Tennis Thin project are included

In 2005, additional 'unauthorized' roads (formerly referred to as 'unclassified' or 'non-system' roads) and existing "temporary" roads were mapped in association with this project. These roads were captured in GIS coverages by Richard Van de Water and transferred to the roads layer used in this analysis. Road attributes were reviewed by Leslie Burkhart and incorporated in this analysis.

'Proposed Action' section exhibits model results for proposed project activities:

Information used for this proposed action was provided in Arc/Info GIS coverages entitled <units_alt2, units_alt3, units_alt4, units_alt5>. These coverages were copied from "K:\gis\project\eis\scott_river\mt_ashland\activities" workspace (7-14-2006 version). Unit attribute information (silvicultural prescription, logging system and post-logging fuel/site prep treatments) were obtained from spreadsheet entitled "Alternative_Summary071306.xls" (7-13-06 version). See Table C (*ALT 2,3,4,5 cwe_sheds_ashland_17jul06.xlx*) for project parameters used in this analysis.

For modeling purposes, the following assumptions were made:

1. For units described as "Handpile/underburn" in 'Fuels Treatment' column, 'underburn' was assumed,
2. For units described as "Mastication/HP" in 'Fuels Treatment' column, 'mastication' was assumed,
3. Units described as "CGB" (combined ground-based) in 'Logging System' column were modeled using coefficients for 'tractor' logging system,
4. Units described as "TE" (tractor end-line) in 'Logging System' column were modeled using coefficients for 'cable' logging system.

With the possible exception of "TE," these assumptions are conservative, in that they tend to over-model CWEs.

Proposed new landing construction is from points coverage <landings>, copied from workspace "K:/gis/project/eis/scott_river/mt_ashland/activities" (7-14-06 version). These points were buffered to create circles using the following dimensions:

Type of landing	Buffer radius, in meters	Acres, approximate
Potential helicopter service	36	1.0
Potential helicopter log	36	1.0
Potential cable/skyline log	25	0.5
Potential tractor log	25	0.5

Locations of these landings are for modeling purposes only and may change during project implementation. Existing landings were not modeled.

Proposed construction of new temporary spur roads was incorporated from coverage <temp_roads>, copied from "K:/gis/project/eis/scott_river/mt_ashland/trans" workspace (7-11-06 version). It is assumed that these roads will be hydrologically stabilized (decommissioned) after use. Existing

unauthorized roads associated with the project were modeled from coverage <project_rds>, copied from "K:/gis/project/eis/scott_river/mt_ashland/trans" workspace (7-17-06 version). These roads will be opened, used during the project, hydrologically stabilized after use and closed.

Proposed new construction of temporary spur roads and landings, and treatments of existing unauthorized roads used in the project vary by action alternative. Details are shown in accompanying spreadsheet called, *cwe_roads_ashland_17jul06.xls*.

'Future [reasonably foreseeable]'

No "reasonably foreseeable future action" were identified or modeled in this analysis.

Important caveats:

Refer to *CWE 2004 - Cumulative Watershed Effects Analysis* (USFS, 2004) for general discussion of this topic.

Direct/indirect and cumulative watershed effects:

Refer to *CWE 2004 - Cumulative Watershed Effects Analysis* (USFS, 2004) for general discussion of this topic.

Watershed inference points:

Refer to *CWE 2004 - Cumulative Watershed Effects Analysis* (USFS, 2004) for general discussion of this topic.

Activities NOT modeled – qualitative discussion may be needed:

Refer to *CWE 2004 - Cumulative Watershed Effects Analysis* (USFS, 2004) for general discussion of this topic.

Recommendations (for further work):

Refer to *CWE 2004 - Cumulative Watershed Effects Analysis* (USFS, 2004) for general discussion of this topic.

Recovery (duration of adverse effects):

Refer to *CWE 2004 - Cumulative Watershed Effects Analysis* (USFS, 2004) for general discussion of this topic.

METHODS

Arc/Info coverages:

CWE process described in this document is GIS based. Arc/Info coverages are therefore referenced in closed triangular brackets, <coverage>, for example. Results of this assessment are shown in tables (MS Excel worksheets) contained in the following files (MS Excel workbook): *ALT 2,3,4,5 cwe_sheds_ashland_17jul06.xlx*. Key coefficients and important assumptions are found in *cwe_coefficients.xls* file. See below for more detailed discussion of the three models used in this assessment.

These coverages extend across the analysis area, which is described under the coverage called <cwe_sheds04>. All coverages are from Forest layers that were "clipped" by analysis boundary for this project. Unless otherwise indicated, coverages extend throughout the analysis area.

[1] <**sheds**> (from <**cwe_sheds04>) -** is a polygon coverage containing 12 7th-field drainages comprising the Beaver Creek 5th-field watershed. This coverage was not clipped to the Forest administrative boundary and includes drainages that contain small percentages of Forest administered lands. Boundary of this coverage defines the 'analysis area' and is stored in a coverage called <**bnd**>.

[2] <**rds**> **-** is a line coverage clipped from the Forest library roads coverage, called <travel_route>. Arcs within this line coverage were attributed from TIS (Transportation Information System) database using an AML (Arc Macro Language) called "rd_cwe.aml." Attributes that were added included: (1) status [e.g., 'EX' for existing, 'DE' for decommissioned], (2) width (road surface width, in feet), (3) road surface material [e.g., native, crushed rock, pit-run rock, asphalt], (4) template [e.g., outsloped, insloped, crowned, flat], and (5) maintenance level [e.g., ML = 1, 2, 3, 4, or 5].

For **classified** (system) roads, 'K' and 'D' values are calculated for individual road segments based on changes in surface type and template. Maintenance level is used as a surrogate for level of use or traffic. Roads with heavy use produce more sediment by surface erosional processes (Reid and Dunne, 1994). Multipliers are employed to integrate use levels. Unspecified roads are assumed (by default) to be native surfaced, flat, and maintenance level 2. County roads were assumed to have 26' width, crushed aggregate surface, crowned and maintenance level 4. State roads were assumed to have 32' width, asphalt surface, crowned and maintenance level 5.

Surface type [modifies 'K']	Value	**Template** [modifies 'D']	Value	**Use** [maintenance level]	Multiplier
native (& unspecified)	"k" soil	unspecified	.29	0 (unspecified)	.5
pit-run aggregate	.10	outsloped	.15	1	.5
crushed aggregate	.02	insloped	.40	2	1
asphalt- pavement	.01	crowned	.40	3	2
chip-seal	.02	flat	.23	4	2
cinders	.05			5	2

[3] <**disturb**> **-** is a polygon coverage that contains harvest and fire watershed disturbances. This coverage represents a compilation of activities generated from four general sources:

1. Past logging activities on Forest Service (FS) administered lands. Information was obtained from the Forest's managed stands layer (<mgstands>). Previous analyses have used only the plantation layer (regeneration harvest). Incorporation of managed stands layer means that partial cuts were modeled, yielding generally higher CWE values.
2. Past logging activities on private industrial timber lands. Polygons were digitized from DOQ (Digital Ortho-quads) images. Activities were assigned a 'year' and harvest 'impact' based on comparison to adjacent dated and described FS activities. Activity 'years' were lumped into decades.
3. Wildfires with burn intensity mapping. Included are the following wildfires: [1] Hog (1977), [2] 1987 Fires (1987), [3] Dillon (1994), [4] Specimen (1994), [5] East (1999), [6] Bark (2000), [7] Crawford (2001), [8] Jones (2001), [9] Larry (2001), [10] Swillup (2001), [11] Creek (2002), [12] Forks (2002), and [13] Stanza (2002).
4. Recent and present activities on FS and private lands. Table A lists projects/activities that were incorporated. Activities on private lands were added on a project-by-project basis and therefore, include only projects within Beaver Creek, Horse Creek, Doggett Creek and South Fork Scott River areas. Information on these private projects was obtained from THP (Timber Harvest Plan) documents. Planning documents (NEPA & ESA) provided information on FS projects.

Recent and present activities are modeled using a combination of the following parameters:

1. **Silvicultural prescription** - Since silvicultural prescriptions very widely between projects, even between units and alternatives in one project, the CWE impact of proposed silvicultural activities is based on the following table:

CWE Impacts Based on Rx	**Basal Area Removed 1/**	**Silvicultural Prescription [Examples]**
HIGH	> 70%	Clear cuts Green tree retention Seed Tree - prep & removal Shelterwood - prep, seed & removal [high quantity removed]
MODERATE	40% – 70%	Overstory removal Group select (heavy) Shelterwood - prep, seed & removal [moderate quantity removed]
LOW	10% - 40%	Commercial thin Group select (light) Single tree select Sanitation Salvage (unit)
NONE	< 10 % live trees	Fire salvage (dead trees) Roadside salvage Pre-commercial thin Hazard tree removal

1/ General guidelines only; basal area removed can depend on existing stocking levels

2. **Logging system** – see tables in MS Workbook (*cwe_coefficients.xls*) for details.
3. **Site preparation** (following logging) - see tables in MS Workbook (*cwe_coefficients.xls*) for details.

[4] <**kcrls**> - is a polygon coverage that combines information necessary to run the USLE model. See below for more details. The coverage includes: (1) soil erodibility, (2) conversion factor, (3) runoff factor, and (4) slope-length steepness factor.

[5] <**geo13**> - coverage was created by the combination of four Forest geological layers: (1) bedrock geology, (2) geomorphology, (3) active landslides, (4) inner gorges (of stream channels), combined with a two-slope-class-DEM-generated coverage (<65% slopes & >65% slopes). This coverage divides the landscape into 15 “geomorphic terranes.” Polygons are coded 0 (for no data), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 17 - corresponding to the “geomorphic terranes." These terranes exhibit different rates of sediment delivery from mass-wasting processes, as determined by the Salmon Sediment Analysis [de la Fuente & Haessig, 1994] and modified for this analysis, using data from the 1997 Flood. <**geo13**> covers all 7.5' quads that contain any KNF administered lands, and therefore, covers the analysis area - including ``checker board" ownership along the eastern margin. However, polygons with no ``geo13" designation were coded “0" for no data and assigned default coefficients of “geo13" number “8" (see below).

<u>USLE model</u> - Surface erosion sediment delivery

Methodology & Assumptions:

Model used in this analysis predicts sediment **delivery** to streams from surface erosion. Model generated values were calculated using the Universal Soil Loss Equation [USLE] or Klamath (modified) Universal Soil Loss Equation [KUSLE], defined by the following equation:

A = [.7]*R*LS*D*K*C

where:

A= estimated soil loss (cy/ac/yr) .7 = converts tons to cubic yards (cy)
R = rainfall/runoff factor LS = slope-length/slope-steepness factor
D = delivery factor K = soil erodibility factor (by Soil Map Unit [SMU])
C = cover factor (from disturbance class)

USLE "estimated soil loss" is calculated in a GIS environment using Arc/Info programming language (Arc Macro Language – "AML"). "AML" (usle.aml) is run on a combined USLE coverage [<usle>]. This overlay was created from the following coverages:

(1) <kcrls> = Forest GIS library layer - integrates the following information:

- Soil erodibility factor ("k") from Forest soils layer, based on 'soil map unit'
- Conversion factor ("c") – converts tons to cubic yards
- Runoff factor ("r") – from formula, r = 10.2*p^2.17, where "p" is maximum 6-hour rainfall with 2-year recurrence interval, in tenth of inch [from NOAA isopluvial mapping of Northern California]
- Slope-length steepness factor ("ls") – 2.50 for slopes less than 35%, 7.32 for slopes greater than 35%. Slope gradients were derived from 30-meter DEMs (digital elevation model) overlain with inner gorge layer.

(2) <disturb> = used to assign "C" factor, based on percent ground cover; includes harvest, fire (wild and prescribed) and road/landing disturbances. See Table A for list of modeled activities. Includes adverse impacts from past, present and future activities and beneficial impacts from road stormproofing and decommissioning.

Delivery coefficients ("D" factor in the USLE equation) were modified for this analysis. Previously, all roads were assigned a "D" factor value of .29; for everything else, "D" factor of .05 was used. For this analysis, roads were given various "D" factor values (ranging from .15 to .40 – see Table above) based on the road template; for everything else, "D" factor of .10 was used. Doubling of general "D" factor value (from .05 to .10) meant that inference point was cut in half – from 800% over background to 400% over background.

Predicted sediment **delivery** is for the first 12 months (year) following project completion. For the surface erosion model, sedimentation rates expressed by the model are realized during a six-hour maximum rainfall with a two-year recurrence interval. In other words, the probability is 50% that a six-hour event will occur in any given year that will produce model-predicted sedimentation rates.

CWE model values are expressed as "**risk ratios**." These ratios are calculated by dividing accelerated sedimentation values by an "**inference point"** value. In the USLE model, accelerated sedimentation is figured as "% over background," which is calculated from 'current' model-estimated sediment delivery

[‘Current’ and ‘Current + proposed + future’ columns] less background [‘Background’ column] divided by background values.

"Background" is a watershed's natural sediment **delivery** assuming no disturbance. "Background" includes land with (1) old harvest units, (2) old fire, (3) young fire, low burn intensity, (4) young harvest, low impact prescriptions, and "pristine." In other words, land with disturbances that have fully recovered, disturbances not modeled, and completely undisturbed land. Background should NOT be confused with “baseline,” which is term used in ESA (Endangered Species Act) consultation and is equivalent to “Current” used in this analysis (i.e., existing conditions prior to proposed action).

GEO model - Sediment delivery from mass wasting processes

This model estimates sediment **delivery** to streams from mass wasting and has its empirical base in the Salmon Sub-basin Sediment Analysis [de la Fuente & Haessig, 1994] and uses methodology developed in Amaranthus et al. [1985], the Grider EIS [USFS, 1989] and KNF LRMP [USFS, 1994]. Model estimates sediment delivery using a matrix of coefficients (see below). Sediment **delivery** coefficients are modified from Salmon Sub-basin Sediment Analysis [de la Fuente & Haessig, 1994] and are based on geomorphic terrane and disturbance. Coefficients were modified for this analysis using 1997 Flood information.

GEO	Mass-wasting model	[Values represent model-estimated sediment delivery in cubic yards / **DECADE**]			
Code	**Description**	**Background (undisturbed)**	**Roads**	**High impact fire or harvest 1/**	**Moderate impact fire or harvest 2/**
0	unknown	0.25	18.27	2.05	1.15
1	Active Landslides	25.92	753.12	94.64	60.28
2	Toe Zone Dormant Slides	1.89	154.53	5.92	3.91
3	Dormant Landslides	1.89	154.53	5.92	3.91
4	Granitic Mtn. Slopes, Steep Slopes (>65%)	1.00	585.40	10.35	5.68
5	Granitic Mtn. Slopes, Low to Moderate Slopes	0.53	35.13	5.50	3.02
6	Non-Granitic Mtn. Slopes, Steep Slopes (>65%)	1.23	81.84	2.50	1.87
7	Goosenest, gentle slopes	0.05	0.50	0.25	0.15
8	Non-Granitic Mtn. Slopes, Low to Moderate Slopes	0.25	18.27	2.05	1.15
9	Inner Gorge on Unconsoildated Deposits	19.94	308.52	42.51	31.23
10	Inner Gorge on Granitic Slopes	6.36	699.46	109.95	58.16
11	Other Inner Gorge	5.14	168.55	8.79	6.97
12	Debris Basins	1.06	25.00	17.00	9.03
13	Glacial Moraine, Terrace and Fan Deposits	2.17	6.38	5.50	3.84
17	Goosenest, steep slopes	0.50	5.00	2.50	1.50

1/ Includes 'GTR' and equivalent silvicultural prescriptions and high/moderate burn intensity wildfire
2/ Includes partial cuts and other moderate impact silvicultural prescriptions
[Revised 30-Jan-04]

GEO "cubic yard/decade" is calculated in a GIS environment using Arc/Info programming language (Arc Macro Language – "aml"). "Aml" (geo.aml) is run on a combined GEO coverage [<geo>]. This overlay was created from the following coverages:

(1) <geo13> = Clip of Forest library layer <geo_terranes>; contains geomorphic terrane polygons listed in table above,

(2) <disturb> = same coverage used for USLE above, except used to assign sediment delivery coefficient value from table above. For example, a road lying on geo13# = 3 would have a sediment delivery coefficient of 225.05 (cy/ac/10yr).

Predicted sediment delivery is for the first decade following project completion. Coefficients recover to background values in 50 years. For the GEO (mass wasting) model, coefficients predict sedimentation volumes from landsliding for a flood event with a recurrence interval of 10 – 20 years. In other words, probability of attaining sedimentation rates of the magnitude predicted by the coefficients is 1 to 10 through 1 to 20 [i.e., 10% - 5% in any given year].

CWE model values are expressed as "**risk ratios**." These ratios are calculated by dividing accelerated sedimentation by an "**inference point"** value. In the GEO model, accelerated sedimentation is figured as "% over background," which is calculated from 'current' model-estimated sediment delivery ['Current' and 'Current + proposed + future' columns] less background ['Background' column] divided by background values.

"Background" is a watershed's sediment **delivery** assuming no disturbance. "Background" includes land with (1) old harvest units (>50yr), (2) old fire (>50yr), (3) young fire (<50yr), low burn intensity, (4) young harvest (<50yr), low impact prescriptions, and "pristine." In other words, land with disturbances that have fully recovered, disturbances not modeled, and completely undisturbed land. Background should NOT be confused with "baseline," which is term used in ESA (Endangered Species Act) consultation and is equivalent to "Current" used in this analysis (i.e., existing conditions prior to proposed action).

ERA - Disturbance index (ERA/TOC)

The ERA/TOC model provides a simplified accounting system for tracking disturbances that affect watershed processes, in particular, estimates in changes in peak runoff flows influenced by ground-disturbing activities. Unlike the surface erosion (USLE) and mass wasting (GEO) models, ERA/TOC is not intended to be a process-based sediment model. It does, however, provide an indicator of watershed conditions.

This model compares the current [&proposed] level of disturbance within a given watershed (expressed as % ERA) with the theoretical maximum disturbance level acceptable (expressed as % TOC). Some use ERA/TOC as a "run off risk" model which estimates the level of hydrological disturbance or relative risk of increased peak flows and consequent potential for channel alteration and general adverse watershed impacts. To determine ERA, coefficients for disturbance classes [types & ages] are compared to values for roads to calculate the area of road that would produce the same changes in peak flows. This information is used to create a table of Equivalent Roaded Area (ERA) coefficients (see KNF EIS, pg. G-9; notes associated with ERA table).

Elder & Laurent (pers. comm., 1998) developed ERA coefficients for use at the project scale. These coefficients were modified from the Jack/Gray EA (Kilgore & Power, 1998) and used relative values from KNF CWE Analysis Handbook (Van de Water, et al., 1990) and from other literature sources. Coefficients were further modified in February 2002 in a meeting of timber project planners and CWE modelers. Coefficients used in this analysis are shown in 'ERA' worksheet of MS Excel file *cwe_coefficients.xls.*

Coefficients are additive. Coefficients for harvest prescription are added to logging system coefficients, which are added site prep coefficients. For example, a tractor logged GTR harvest unit with tractor piling of slash would have a total ERA coefficient of **.12** (GTR Rx) + **.04** (tractor logging - modified) + **.03** (mastication) = **.19** (total ERA per acre). Helicopter logged commercial thin with hand piling site preparation would have a total ERA coefficient of **.03** (CT Rx) + **.001** (helicopter logging system) + **.001** (hand piling) = **.032** (total ERA per acre).

TOC (threshold of concern) is a measure of watershed sensitivity. TOC is calculated based on channel sensitivity, beneficial uses, soil erodibility, hydrologic response, and slope stability of each watershed. For example, a watershed with sensitive channels, highly productive anadromous streams (high beneficial use), highly erodible soils, high landslide densities &/or high percentage of granitic lands (slope stability), and high percentage of watershed in the "rain-on-snow" zone (~3,500' to 5,000' elevation; hydrologic response) would have a high "watershed sensitivity level" and therefore a low TOC. An ERA/TOC ratio approaching or greater than 1.00 serves as a “yellow flag” indicator of increasing susceptibility for significant adverse cumulative effects occurring within a watershed. Susceptibility of CWE generally increases from low to high as the level of land disturbing activities increase towards or past an ERA/TOC value of 1.00 (USFS, 1988). TOC values for the analysis watersheds were taken from the Klamath National Forest CWE Assessment 2002 (USFS, in prep.). Individual 7th-field drainage TOC values for each parameter are shown in Table B. Evaluating existing condition of benefiting resources in the analysis area should validate these values. Differences with those shown in (NMFS) matrix of pathways and indicators should be explained.

CWE model values are expressed as “**risk ratios**.” These ratios are calculated by dividing ERA values by an “**inference point”** value. In the ERA/TOC model, ERA values are divided by the TOC value for each watershed (see Table B for these values and parameters used to calculate them).

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