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Subject: Soil Specialist Report for Salmon-Moose Fuels Reduction Project
To: Terry Hershey, District Ranger

Attached is the soils specialist report for the Salmon-Moose Fuels Reduction Project. The report includes a description of the existing condition and an analysis of the effects of a no-action and two action alternatives.

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Soil Resources

Affected Environment

Introduction

Impacts to soil resources from fuels reduction and vegetation management activities were identified as a resource concern during scoping. Logging, thinning and burning have the potential to adversely affect soil resources by causing detrimental soil disturbances, reducing long-term soil productivity, and adversely affecting landform stability.

This section describes the *existing* condition of soil resources relative to soil quality and detrimental soil impacts, long-term soil productivity and nutrient availability, and slope stability within the proposed project area. The analysis area for soils resources is the same as the proposed project area (37,070 acres).

Measurement indices used to compare alternatives and analyze the effects of fuels reduction and vegetation management activities to soil resources include the following:

- Percent detrimental soil disturbance within a defined activity area.
- Percent total soil resource commitments within a defined activity area.
- Average tons per acre of Coarse Woody Debris retained within proposed treatment units.
- Acres of treatments with high potential for slope instability.

Information about soil resources within the analysis area was obtained from the Land Systems Inventory for the Salmon National Forest (USDA 1978), field investigations, and laboratory analysis.

Maps 34-36 display the landtypes delineated within the analysis area, with the proposed treatment units for each alternative. Landtypes are the basic units for overall land use study and planning. They are the visually identifiable unit areas resulting from homogeneous geomorphic and climatic processes, and having defined patterns of soils and vegetation potentials. Table 1 displays the landtype name, the acreages of the delineations, and the percent composition of delineations within the analysis area. Table 22 displays the acres of proposed vegetation treatments by landtype and the erosion hazard and slope stability ratings for these landtypes.

Table 1 Landtype, Acreage, and Percent Composition

Landtype Unit Name	Acres	% Composition
G109 Moderately Dissected Cryic Basinland in Granite, Moist Sites	18.2	0.1
G109a Weakly Dissected Slopeland in Granite, Cool and Moist Sites	60.9	0.2
G109j Weakly Dissected Mountain Slopeland in Granite, Cool-Moist Sites	3492.3	9.4
G110d Steep Rocky Cirque Headwall in Granite	364.5	1.0
G110w Cirque Basinland in Granite, Moist to Wet Sites with Lakes	99.0	0.3
G120a Weakly Dissected Mountain Slopeland in Granite, Cool and Moist Sites	367.1	1.0

Table 1 Landtype, Acreage, and Percent Composition

Landtype Unit Name	Acres	% Composition
G120b Moderately Dissected Mountain Slopeland in Granite, Cool-Moist Sites	635.2	1.7
G120bs-1 Moderately Dissected Mountain Slopeland in Granite, Warm-Dry Sites	938.5	2.5
G120cr Rocky, Strongly Dissected Mountain Slopeland in Granite	484.9	1.3
G120cs Strongly Dissected Mountain Slopeland in Granite, Hot and Dry Sites	630.2	1.7
G120cs-1 Strongly Dissected Mountain Slopeland in Granite, Warm-Dry Sites	1106.5	3.0
G120d Steep, Timbered Headlands in Granite, Cold and Moist Sites	151.5	0.4
G124n Steep, Timbered Canyonland in Granite, Cool and Moist Sites	473.4	1.3
G124r Rocky, Steep Canyonland in Granite, Hot and Dry Sites	620.6	1.7
Q109 Cryic Ridgeland in Quartzite, Moist Sites	1879.6	5.1
Q109b Moderately Dissected Cryic Mountain Slopeland in Quartzite, Moist Sites	2812.4	7.6
Q109d Cryic Headlands in Quartzite, Moist to Wet Sites	1273.3	3.4
Q109j Moderately Dissected Cryic Basinland in Quartzite, Moist Sites	1194.1	3.2
Q120a Weakly Dissected Mountain Slopeland in Quartzite, Cool and Moist Sites	2277.4	6.1
Q120ar Weakly Dissected, Rocky, Mountain Slopeland in Quartzite	283.4	0.8
Q120as Weakly Dissected Mountain Slopeland in Quartzite, Hot and Dry Sites	178.9	0.5
Q120as-1 Weakly Dissected Mountain Slopeland in Quartzite, Warm-Dry Sites	138.4	0.4
Q120at Weakly Dissected Scree Mountain Slopeland in Quartzite	286.9	0.8
Q120b Moderately Dissected Mountain Slopeland in Quartzite, Cool-Moist Sites	3661.7	9.9
Q120bs Moderately Dissected Mountain Slopeland in Quartzite	282.1	0.8
Q120bs-1 Moderately Dissected Mountain Slopeland in Quartzite, Warm-Dry Sites	1572.7	4.2
Q120c Strongly Dissected Mountain Slopeland in Quartzite, Cool and Moist Sites	2663.5	7.2
Q120cs Strongly Dissected Mountain Slopeland in Quartzite, Hot and Dry Sites	2014.0	5.4
Q120cs-1 Strongly Dissected Mountain Slopeland in Quartzite, Warm and Dry Sites	751.7	2.0
Q120d Steep, Timbered Headlands in Quartzite, Moist to Wet Sites	2115.6	5.7
Q120dr Steep, Rocky Headlands in Quartzite	33.8	0.1
Q124n Steep, Timbered Canyonland in Quartzite	229.6	0.6
Q124r Rocky, Steep Canyonland in Quartzite, Hot and Dry Sites	910.0	2.4
Q124s Steep Canyonland in Quartzite, Hot and Dry Sites	298.8	0.8
Q126as Weakly Dissected Foothills in Quartzite	98.8	0.3
V109j Moderately Dissected Basinland in Volcanics, Moist Sites	280.4	0.8
V120b Moderately Dissected Mountain Slopeland in Volcanics, Cool - Moist Sites	148.9	0.4
V120cs Strongly Dissected Mountain Slopeland in Volcanics, Hot and Dry Sites	1194.1	3.2
V120d Steep Timbered Headlands in Volcanics, Moist to Wet Sites	224.2	0.6
V124r Rocky, Steep Canyonland in Volcanics, Hot and Dry Sites	327.8	0.9
V124s Steep Canyonland in Volcanics, Hot and Dry Sites	135.4	0.4
VB Valley Bottomland	359.4	1.0
Totals	37,070	~100

Landtype units where proposed treatment units are planned are most critical to this analysis. Table 2 displays the landtype units, their soil erosion hazard and stability ratings, and the proposed treatment units and acres for Alternative 2.

The erosion and stability ratings are to be used to assess the potential for erosion and mass failure. Soils having a high inherent erosion hazard rating will not necessarily exhibit a high rate of erosion. The inherent erosion hazard ratings are determined for bare soil conditions according to five qualitative classes. The classes are based on the ability of the soils to take in water, the resistance of the soil surface to dispersion under the impact of rainfall and surface water movement, the effect of coarse fragments that reduce surface detachment, and the effect of topography. Climate was considered a constant.

Ratings for three types of mass stability are provided: debris slides, slumps, and surface creep. Debris slides are the failures of accumulations of materials in confined drainages. Slumps are lineal or bow-shaped failures, and surface creep is the down-slope movement of the surface soil which eventually accumulates in draws and is subject to movement as debris slides (USDA 1978).

Table 2 Landtype, Erosion Hazard/Mass Stability Ratings, and Treatment Units

Landtype Units	Erosion Hazard and Mass Stability Ratings	Treatment Units[1]
G109j Moderately Dissected Cryic Basinland in Granite, Moist Sites	Moderate inherent erosion hazard, very low debris slide hazard, very low slump hazard, low surface creep hazard. Low to moderate sediment source when soil is disturbed.	02-M, 11-M, 12-M, 13-M, 18-M, 19-M **93 Acres**
G120a Weakly Dissected Slopeland in Granite, Cool and Moist Sites	Moderate to high inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low to low surface creep hazard. Low to moderate sediment source when soil is disturbed.	26-S, 53-S, 54-S **140 Acres**
G120b Weakly Dissected Mountain Slopeland in Granite, Cool and Moist Sites	Moderate to high inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low to low surface creep hazard. Low to moderate sediment source when soil is disturbed.	20-S, 53-S **34 Acres**
G120bs-1 Moderately Dissected Mountain Slopeland in Granite, Warm and Dry Sites	Moderate to high inherent erosion hazard, low to moderate debris slide hazard, very low slump hazard, moderate to high surface creep hazard. Moderate to high sediment source when soil is disturbed.	54-S, 59-S **90 Acres**
G120cs-1 Strongly Dissected Mountain Slopeland in Granite, Warm and Dry Sites	High inherent erosion hazard, low to moderate debris slide hazard, very low slump hazard, moderate to high surface creep hazard. Moderate to high sediment source when soil is disturbed.	31-S, 51-S, 52-S, 53-S, 56-S, 58-S, 63-S, 700-S **159 Acres**

[1] Acres are approximate and were estimated based on GIS calculations. They are within approximately 1 percent of the total acres within proposed treatment units (Alternative 2).

Table 2 a Landtype, Erosion Hazard/Mass Stability Ratings, and Treatment Units

Landtype Units	Erosion Hazard and Mass Stability Ratings	Treatment Units[1]
G120d Steep Timbered Headlands in Granite, Cool and Moist Sites	High inherent erosion hazard, low debris slide hazard, very low slump hazard, low to moderate surface creep hazard. The potential for creating a sediment source by soil disturbing activities is high.	28-S **15 Acres**
G124n Steep Timbered Canyonland in Granite, Cool and Moist Sites	High inherent erosion hazard, moderate debris slide hazard, very low slump hazard, moderate surface creep hazard. Moderate to high sediment source when soil is disturbed.	53-S **14 Acres**
G124r Rocky Steep Canyonland in Granite, Hot and Dry Sites	Very high inherent erosion hazard, high to very high debris slide hazard, very low slump hazard, high to very high surface creep hazard. Very high sediment source when soil is disturbed.	53-S **10 Acres**
Q109 Cryic Ridgelands in Quartzite, Moist Sites	Low inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low surface creep hazard. Low sediment source when soil is disturbed.	20-M, 21-M, 22-M, 24-S, 25-S, 27-S, 29-S **97 Acres**
Q109b Moderately Dissected Cryic Mountain Slopeland in Quartzite, Moist Sites	Low to moderate inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low surface creep hazard. Low to moderate sediment source when soil is disturbed.	01-M, 03-M, 04-M, 05-M, 06-M, 08-M, 09-M, 10-M, 14-M, 15-M, 16-M, 17-M, 20-M, 21-M, 22-M, 30-S, 52-M **255 Acres**
Q109j Moderately Dissected Cryic Basinland in Quartzite, Moist Sites	Low inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low surface creep hazard. Low sediment source when soil is disturbed.	06-M, 07-M, 18-M, 52-M, 53-M **125 Acres**
Q120a Weakly Dissected Mountain Slopeland in Quartzite, Cool and Moist Sites	Moderate inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low surface creep hazard. Low sediment source when soil is disturbed.	06-S, 07-S, 09-S, 10-S, 11-S, 12-S, 14-S, 15-S, 16-S, 23-S, 26-S, 31-S, 50-S, 51-S, 53-S, 54-S, 56-S, 60-S **311 Acres**
Q120as-1 Weakly Dissected Mountain Slopeland in Quartzite, Hot and Dry Sites	Moderate inherent erosion hazard, low debris slide hazard, very low slump hazard, moderate surface creep hazard. Moderate sediment source when soil is disturbed.	56-S **10 Acres**
Q120b Moderately Dissected Mountain Slopeland in Quartzite, Cool and Moist Sites	Moderate inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low soil creep hazard. Moderate sediment source when soil is disturbed.	01-S, 02-S, 03-S, 04-S, 18-S, 19-S, 20-S, 21-S, 22-S, 24-S, 25-S, 29-S **179 Acres**
Q120c Strongly Dissected Mountain Slopeland in Quartzite, Cool and Moist Sites	Moderate inherent erosion hazard, very low debris slide hazard, very low slump hazard, very low surface creep hazard. Moderate sediment source when soil is disturbed.	04-S, 05-S, 30-S, 61-S, 62-S **39 Acres**
Q120d Steep Timbered Headlands, Moist to Wet Sites	Moderate inherent erosion hazard, low debris slide hazard, very low slump hazard, low to moderate surface creep hazard. Moderate sediment source when soil is disturbed.	07-S, 08-S, 09-S, 13-S, 17-S, 28-S, 30-S **69 Acres**

Table 2 Landtype, Erosion Hazard/Mass Stability Ratings, and Treatment Units

Landtype Units	Erosion Hazard and Mass Stability Ratings	Treatment Units[1]
V120cs Strongly Dissected Mountain Slopeland in Volcanics, Hot-Dry Sites	Moderate to high inherent erosion hazard, low debris slide hazard, low slump hazard, moderate surface creep hazard. Moderate to high sediment source when soil is disturbed.	700-S **10 Acres**

Soil Quality, Detrimental Disturbances, and Total Resource Commitments

Fuels reduction and vegetation management activities can detrimentally alter natural soil conditions, resulting in the degradation of soil quality and productivity. Forest Plan direction states that soil resources will be managed to maintain soil productivity, minimize man-caused erosion, and maintain the integrity of associated ecosystems (LRMP IV-57). Site productivity will be protected and/or maintained at a level equal to or greater than 90 percent of natural conditions (LRMP IV-90). This is achieved by (a) limiting detrimental soil disturbances to no more than 20 percent of an activity area[2] following project implementation (regional guidelines recommend that at least 85 percent of an activity area be maintained in a non-detrimentally disturbed condition), and (b) limiting total soil resource commitments to no more than 5 percent of an activity area (LRMP IV-60 and 61).

Detrimental Soil Disturbances

A detrimental soil condition occurs when soil hydrologic function and site productivity are adversely affected. Detrimental soil disturbance is defined as the alteration of natural soil physical characteristics that results in immediate and /or prolonged violations of off-site resource quality standards. Soil compaction, puddling, and displacement are examples of detrimental soil disturbance (USFS 1988:IV-60). Detrimental soil disturbance can also occur during fires when soils are severely burned and the entire organic soil surface is consumed to bare mineral soil.

The activity area for determining detrimental soil disturbances from management actions consists of the acres within the proposed vegetation treatment units (Appendix E). Alternative 2 proposes to treat 1,670 acres, Alternative 3 proposes to treat 1,553 acres, and Alternative 4 proposes to treat 1,486 acres during the next several years. Of the acres proposed for treatment, 475 acres have been previously harvested or thinned (Appendix E).

Soil condition evaluations and qualitative soil management assessments of eleven previously harvested units within the project area were conducted to assess physical and biological soil condition ratings. Soil health indicators to determine these ratings include compaction estimates, hydrophobicity, surface erosion, effective ground cover, and soil

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[2] An activity area is defined as a land area impacted by a management activity. It may be a harvest unit within a timber sale area, a prescribed burn unit, or a grazing area within a range allotment (FSH 2509.18 – Soil Management Handbook, R4 Supplement 2509.18-95-1).

displacement. The evaluation encompassed about 265 acres within the project area. (Copies of these evaluation forms are included in the project file.)

No visual evidence of detrimental soil compaction, such as obvious runoff from reduced water infiltration, stunted growth of young trees, and poorly revegetated skid trails from past harvest activities, was observed in any of the previously harvested areas. Soil displacement was observed in two previously harvested units; one unit had been scarified and about 20 acres of soil displacement was apparent throughout the unit, while the other had minor soil displacement along one short readily identifiable skid trail totaling less than one acre.

Soil bulk density samples collected from skid trails and landings from four timber sales during 2002 and 2003 in other areas of the Forest with similar landforms and soils showed that detrimental soil compaction as a result of harvest activities is not an extensive problem. Of the 14 bulk density samples and 30 soil penetrometer readings collected, only one sample was approaching the threshold of detrimental soil compaction according to the definition presented in Region 4 Supplement r4_2509.18-2002-1 to the Soil Management Handbook (sampling results are included in the project file.)

Additionally, reports from annual timber sale monitoring reviews, conducted on the Forest by the Forest Soil Scientist and Forest Hydrologist from 1990 through 1997, were evaluated to determine the extent of detrimental soil disturbances caused by timber harvesting and associated activities. These reports provide a qualitative assessment of post-sale conditions and the implementation and effectiveness of Best Management Practices (BMPs) used to mitigate effects of timber harvest. Although these timber sales are not within the proposed project area, the landforms and soils are similar. Of the 17 timber sales reviewed during the eight-year period, soil compaction requiring treatment on skid trails, landings, and/or old roads was identified three times. Excessive soil displacements caused by skidding or slash piling and the presence of hydrophobic soils caused by burning slash piles were each identified twice. (Copies of these reports are in the project file). Conclusions from these narrative monitoring reports indicate that compaction, displacement, and the presence of hydrophobic soils from burning slash piles are not extensive and BMPs used to mitigate adverse impacts are effective.

Since it is not possible to sample or evaluate every acre that has been previously harvested within the proposed project area to determine the exact extent of existing detrimental soil disturbances, a factor of 5 percent per previously harvested acre (for tractor logging) is used to calculate a reasonable estimate of detrimental disturbances caused by past harvest activities. Professional judgment, literature review, monitoring data, and site-specific field observations were considered when determining this factor.

The calculated level of *existing* detrimental soil disturbances within the proposed treatment units (activity areas) as a result of past logging activities is approximately 24 acres. Surface compaction, puddling, and hummocking impacts as a result of livestock use have been observed throughout the analysis area. Occular estimates of detrimental disturbances occur on about 300 acres (50% of the areal extent) of proposed aspen treatment units 52-M, 53-M, 53-S, 54-S, and 59-S. Impacts are especially evident in Deriar, Wallace, and Diamond creeks where livestock congregate for shade, water, and forage. Bulk density measurements and qualitative evidence indicate that soil

compaction and soil puddling from livestock use have reduced soil productivity in these areas, although the threshold for "detrimental" soil compaction (FLRMP IV-60) is not exceeded in all cases.

Total Soil Resource Commitments

Total soil resource commitment is defined as the conversion of a productive site to an essentially non-productive site for a period of more than 50 years. Inadequately restored haul roads, truck roads, and permanent landing areas, as well as higher standard roads (system or non-system) and some stock drive-ways generally represent an essentially total commitment of the soil resource (USFS 1988:IV-61).

There are approximately 148 miles of open road (open yearlong), 82 miles of closed roads, and 24 miles of seasonal roads within the project area. Based on a calculation of 2 acres of total resource commitment per mile of Forest Service road (T. Beke, USFS, personal communication) the current total resource commitment for the entire project area is 508 acres or 1.4 percent of the 37,070-acre project area.

Soil Productivity

Although not specifically addressed by a Forest Plan standard, another important component of soil productivity is the presence of organic matter and coarse woody material on site. Organic matter is particularly important for water retention, cation exchange, nutrient cycling, and erosion control (Page-Dumroese et al. 1991). Coarse woody debris is important for maintaining long-term soil productivity, and is defined as material larger than three inches in diameter (Graham 1994). Based on the research publication *Managing Coarse Woody Debris in the Rocky Mountains* (Graham et al. 1994), retaining 4 to 15 tons of coarse woody material per acre is recommended for treatment units within the project area, depending on forest type and fire return interval. The need to retain adequate coarse woody debris within harvest units for long-term soil productivity has been identified as a concern during previous timber sale monitoring reviews.

Seven previously harvested units within the project area were evaluated to determine the existing level of coarse woody debris. One of the seven assessed units did not contain sufficient coarse woody debris to maintain long-term soil productivity. Additionally, the evaluation of BMP monitoring reports for 17 timber sales also indicated the need to maintain more coarse woody debris. In those reports, the need for more coarse woody debris in previously harvested units across the Forest was identified six times. Over the entire project area, however, there is adequate (and in many cases excessive) coarse woody debris on the landscape to maintain long-term soil productivity. Excessive woody debris can create an unnatural accumulation of fuels, increasing the risk of wildfire. Fuel accumulations within the proposed treatment units range from 6 to 29 tons per acre. An analysis of the fuels situation is described in the "Fuels" section of this document.

Landform and Slope Stability

Mass instability or landslides are naturally occurring disturbances that can influence the analysis area. Landslide is a collective term that includes both deep-seated, geologic failures and smaller localized mass erosion events such as debris slides, slumps, and surface creep.

Approximately 5,475 acres or about 15 percent of the analysis area has high hazard ratings for debris slides, slumps, and/or surface creep. These occur primarily on landtypes formed from granitic and volcanic parent materials. Several large mass failures have occurred in the Dump Creek drainage. A catastrophic flood event caused by past mining in the late 1800s created a deep chasm in the drainage and slope failures have occurred on the scarp face. The landtypes in this area are V120d (Steep Timbered Headlands in Volcanics, Moist to Wet Sites) and V109j (Moderately Dissected Basinland in Volcanics, Moist Sites).

Environmental Consequences to Soil Resources

This section of the document discloses the direct, indirect, and cumulative effects to soil resources of the No Action Alternative and the three action alternatives. The analysis focuses on detrimental soil disturbances, total soil resource commitments, soil productivity, and landform stability.

Alternative 1 – No Action

Detrimental Soil Disturbances

Direct and Indirect Effects: Fuels reduction and vegetation treatments would not be implemented. As a result, live and dead fuels would continue to accumulate within the analysis area, increasing the risk of severe wildfire. The probability of detrimental soil disturbances, such as severely burned soils and displacement from accelerated erosion, would increase as the risk of severe wildfire increases over time.

The National Soil Management Handbook (SMH) defines severely burned soil as a condition where most woody debris and the entire forest floor are consumed down to bare mineral soil. Soil may have turned red due to extreme heat. Also, fine roots and organic matter are charred in the upper one-half inch of mineral soil (FSH 2509.18, Chapter 2.05). Severely burned soils and high burn severity are not synonymous. Severely burned soils are a detrimental soil impact, which is limited by Forest Plan Standards to maintain or improve soil quality.

"Burn severity" relates specifically to effects of fire on soil conditions and hydrologic function (e.g. amount of surface litter, erodibility, infiltration rate, and runoff response). Although burn severity is not primarily a reflection of effects of fire to vegetation, vegetative conditions and pre-fire vegetation density are among indicators used to assess burn severity (Davis and Holbeck 2001). Site indicators used to evaluate and map burn severity include size of residual fuels, ash depth and color, soil texture, structure, and soil hydrophobicity. These criteria indicate fire residence time, depth of litter layer consumed, radiant heat throughout the litter layer, ease of detachability of the surface soil, and permeability. Using these indicators, burned areas are mapped as a mosaic of three relative burn severity categories. These categories are high, moderate, and low/unburned. Areas mapped with high burn severity occur where 40 percent or more of a specific area exhibits site indicators characteristic of high intensity fire (FSH 2509.23.32a).

During the summer of 2000, the Clear Creek Fire burned approximately 204,000 acres of Forest System lands on the Salmon-Challis National Forest and 1,878 acres of adjoining private lands. The Clear Creek Fire did not burn within the Salmon-Moose Fuels Reduction Project analysis area, but the fire did burn in adjacent watersheds with similar topography, vegetation and fuels conditions. The Fenster Fire also burned during the summer of 2000. This was a much smaller fire, which burned 1,655 acres within the Salmon-Moose Fuels Reduction Project analysis area.

The Burned Area Emergency Response (BAER) Report for the Clear Creek Fire indicates that 10,319 acres were classified as high burn severity. The Fenster BAER Report indicates that 31 acres of high burn severity occurred along Wallace Creek. Neither report identified severely burned soils.

The risk of severe wildfire considered in combination with the erosion hazard rating of soils and landtypes within the analysis area were used to assess the potential for erosion and sedimentation following a severe wildfire. About 26 percent or 9,555 acres within the analysis area are landtypes that have a high inherent erosion hazard rating, indicating that unprotected bare soil will erode sufficiently to severely damage productive capacity or will yield high volumes of sediment (USDA 1978). If a severe wildfire fire occurred within the analysis area, particularly in areas with a high erosion hazard, the potential for erosion and sedimentation would be substantial.

Current Forest policy is to suppress all wildfires outside of designated Wilderness areas. Fire suppression activities such as handline and dozerline construction would increase soil displacement; these effects would, however, be almost entirely mitigated through fireline rehabilitation. Monitoring the recovery of rehabilitated fire suppression activities from the Clear Creek Fire shows that rehabiltation is extemely effective and soil and vegeation recovery can occur within two years (USFS 2002).

The existing level of detrimental soil compaction from past harvest activities is expected to remain the same as the existing condition for the immediate future. Over time, soil compaction would decrease from frost heaving, plant establishment, and loosening of the soil by rodent activity. The level of detrimental soil displacement and puddling from livestock use is also expected to stay the same.

Total Soil Resource Commitments

Direct and Indirect Effects: Because road closures and decommissioning would not be implemented, total soil resource commitments would not be affected and would remain at 1.4 percent of the entire project area.

Table 23 displays the existing acres and percent Total Soil Resource Commitment (TSRC) for each treatment unit (activity area). Currently, treatment unit 07-M does not meet the Forest Plan Standard of limiting total soil resource commitments to less than 5 percent of the activity area. The roads that exist in that treatment unit were constructed as timber haul roads prior to when the Forest Plan was approved in 1988.

Table 3 Total Soil Resource Commitments by Activity Area

Treatment Unit	Acres of Existing TSRC	Percent TSRC by Activity Area	Treatment Unit	Acres of Existing TSRC	Percent TSRC by Activity Area
01-M	0.96	3.8	21-M	0.54	1.4
02-M	0.46	4.6	23-S	0.12	0.8
02-S	0.64	2.6	24-S	1.18	3.2
04-M	0.28	2.3	25-S	0.64	1.6
06-M	0.24	0.96	26-S	0.36	1.1
06-S	0.01	0.07	28-S	0.12	0.75
07-M	2.78	6.9	29-S	0.22	1.2
08-S	0.46	1.3	30-S	0.74	4.1
09-S	0.22	1.0	31-S	0.52	2.0
11-M	0.58	1.1	50-S	0.18	2.2
11-S	0.46	2.5	51-S	0.30	5.0
12-M	0.48	1.3	52-M	0.06	0.28
12-S	0.02	0.06	52-S	1.6	4.8
14-M	0.08	0.32	53-M	0.50	1.2
15-S	0.36	2.0	53-S	8.36	3.8
16-M	0.02	0.13	54-S	1.98	3.1
17-M	0.12	0.6	56-S	1.86	4.5
18-M	0.34	0.85	58-S	0.62	4.7
18-S	0.86	4.3	59-S	4.16	4.5
19-M	0.70	2.1	60-S	0.12	1.2
19-S	0.04	0.5	62-S	0.26	2.6
20-M	0.02	0.06	63-S	1.22	4.9
20-S	0.96	3.2	700-S	0.50	1.3

Treatment units not identified above do not contain any roads, therefore TSRC in those units in 0.

Soil Productivity

Direct and Indirect Effects: The maintenance and restoration of nutrient cycling, decomposition processes, and nutrient supply from vegetation are important for sustaining soil productivity and are dependent in part on having sufficient amounts of woody material on site. Levels of coarse woody debris within the analysis area would continue to accumulate over time in the absence of wildfire. In the event of a wildfire, the level of coarse woody debris would be reduced. The reduction would depend on the size, severity, and duration of the fire.

Landform and Slope Stability

Direct and Indirect Effects: No fuels reduction, vegetation treatments, or road closures or decommissioning would be implemented. Landform stability within the analysis area would not be affected. Severe wildfire has the potential to adversely affect landform stability, depending on wildfire severity and extent (acres burned), and climatic conditions following the fire event (occurrence of high intensity storms).

Alternative 2

This alternative proposes to treat 1,670 acres of lodgepole pine, Douglas-fir and aspen by mechanically harvesting saw timber and post and pole material primarily with tractor logging systems. Slash disposal methods include hand-piling and machine-piling and jackpot burning. This alternative would result in 102 miles of open roads, 135 miles of closed roads, and 16 miles of seasonally closed roads. Of the 254 miles of roads in the project area, 21 miles would be decommissioned as part of this alternative.

Detrimental Soil Disturbances

Direct and Indirect Effects: Log skidding, decking, and slash disposal would cause some detrimental soil compaction, displacement, and severely burned soil; however, design features and site-specific mitigation measures would minimize the effects of the proposed treatments to soil resources. These design features and mitigations are described in the "Alternatives" and include limiting the number of skid trails, scarifying and reclaiming compacted skid trails and landings, and avoiding ground disturbing activities when soils are wet.

Detrimental soil disturbances, particularly detrimental soil comapaction and detrimental soil displacemental, are concentrated primarily at log landings since forest products from specific treatment units are skidded and decked at the landings. Preliminary landing locations have been identified for each treatment unit. Tables displaying the unit number, acres of treatment, logging method, number of landings for each unit, and the size of the landings are included in the project file. Approximately 68 landings totaling 12 acres would be needed for Alternative 2. The areal extent of landings would be less than one percent of the treated area for this alternative. All landings that are detrimentally compacted or have detrimental soil displacement, according to the definitions set forth in the Regional Soil Quality Standards, would be rehabilitated by scarifying or ripping the soil to restore proper water infiltration, redistributing displaced topsoil, seeding with native species, and mulching.

Soil disturbance factors for the various treatments and activities and the calculations used to determine the level of detrimental soil disturbances for the each proposed treatment unit are included in Appendix D. The calculated level of detrimental soil disturbance for each proposed harvest unit is consistent with the Forest Plan Standard of limiting detrimental soil disturbances to no more than 20 percent of an activity area following project implementation. Six treatment units exceed the Regional recommendation of limiting detrimental soil disturbances to no more than 15 percent of an area: Units 01-S, 06-S, 10-S, 21-M, 24-S, and 56-S. Five additional units (Units 18-S, 50-S, 51-S, 58-S and 60-S) are approaching the 15 percent threshold. Unit 21-M and 56-S are of particular concern, since portions of these treatment units have high inherent erosion hazard ratings. Site-specific implementation and effectiveness monitoring would be conducted in these units to ensure that design features and mitigation measures effectively limit erosion in areas with a high inherent erosion hazard.

Total Soil Resource Commitments

Direct and Indirect Effects: No new road construction or permanent landings and skid trails that would convert productive sites to a condition of total soil resource commitment

are planned as part of the proposed action. Approximately 21 miles of road would be decommissioned using a variety of treatment methods (Appendix A). The method selected for each road segment included consideration of soils resource impacts and was selected to reduce total resource commitment over the long term. The long term anticipated outcome of these decommissioning actions would be to restore 42 acres of roads to a productive condition. The level of total resource commitments would be reduced from 1.4 percent to 1.25 percent of the project area as a result of road decommissioning.

As stated above, this alternative would decommission about 21 miles of road. About 0.27 mile of road in unit 07-M would be decommissioned, reducing total soil resources commitments to 5.6 percent within the activity area. Road decommissioning would also occur in treatment unit 04-M, 11-M, 12-M, and 59-S reducing the level of total soil resource commitments in these units. These units comply with the Forest Plan Standard with or without decommissioning. All treatment units except Unit 07-M comply with the Forest Plan Standard of limiting Total Soil Resource Commitments to no more than 5 percent of the defined activity area. The level of Total Soil Resource Commitments improves as a result of decommissioning under this alternative compared to the existing condition.

Soil Productivity

Direct and Indirect Effects: Slash retention within treatment units would provide sufficient coarse woody debris to maintain long-term soil productivity. Four to 15 tons of woody debris per acre would be retained after slash disposal treatments. Slash disposal by jackpot burning would facilitate nutrient cycling on areas that burn at low intensity; however, localized areas of severely burned and hydrophobic soil can be expected where large slash accumulations are burned. Areas of high intensity burning associated with slash disposal were considered when calculating detrimental soil disturbances.

Nutrient changes often occur during combustion, including slash burning. Two differences relative to the discussion of nutrients include total site nutrient budgets versus soil-borne nutrients, and total nutrients versus available nutrients. Sites with large volumes of woody material have substantial portions of site budgets bound in organic matter, in forms unavailable to plants. When this material burns, a large amount of nutrients may remain on-site as ash, may be blown away as fly ash or washed away during overland flow, or may volatilize and leave the site in gaseous form. When bound nutrients leave the site, the site budget is decreased, but the soil reservoir may remain unchanged (Owensby and Wyrill, 1973, as cited by Clark 2001). Although part of a nutrient's budget may be removed, the remaining portion may be converted into a different form that is more available to plants. This is often the case with nitrogen, which volatilizes at low temperatures. When volatilization occurs, the site budget decreases but generally the ammonium form (NH_4^+), which is useable by plants, increases (Clark 2001). Increases of useable forms of nitrogen are expected as a result of low intensity burning during slash disposal, which acts as a soil fertilizer, increasing plant growth.

Landform and Slope Stability

Direct and Indirect Effects: Proposed fuels reduction or vegetation treatments would occur on 10 acres of a landtype with a high to very high debris slide hazard (G124r in the

eastern edge of Unit 53-S). No treatments would occur within landtypes that have a high slump hazard. About 290 acres of proposed treatments would occur on four landtypes (G120bs-1, G120cs, G120cs-1, and G124r) that have moderate to high surface creep[3] hazard. Proposed design features, including leaving adequate coarse woody debris on-site, would result in no adverse effect to landform and slope stability in the proposed treatment units.

No fuels reduction or vegetation treatments that could contribute to landform or soil instability would occur within one-half mile of the Dump Creek chasm. Two units planned for treatment in that area were eliminated from the original proposal so that instability along the chasm would not worsen.

Alternative 3

This alternative proposes to treat 1,553 acres of lodgepole pine, Douglas-fir, and aspen by mechanically harvesting saw timber and post and pole material with tractor or cable logging systems. Associated slash disposal methods include hand or machine piling and jackpot burning. This alternative would result in 156 miles of open roads, 85 miles of closed roads, and 10 miles of seasonally closed roads. Of the 254 miles of roads in the project area, 13 miles would be decommissioned as part of this alternative.

Detrimental Soil Disturbances

Direct and Indirect Effects: The direct and indirect effects associated with log skidding, decking, and associated slash disposal would be similar to those described for Alternative 2. Design features and site-specific mitigation measures would minimize the effects of the proposed treatments to soil resources and are described in Chapter 2 of this document.

Preliminary landing locations have been identified for each treatment unit. Tables displaying the unit number, acres of treatment, logging method, number of landings for each unit and the size of the landings are included in the project file. Approximately 64 landings totaling about 11 acres would be needed to implement Alternative 3. The areal extent of landings would be less than one percent of the treated area for this alternative. All landings that are detrimentally compacted or have detrimental soil displacement according to the definitions set forth in the Regional Soil Quality Standards, would be rehabilitated by scarifying or ripping the soil to restore proper water infiltration, redistributing displaced topsoil, seeding with native species, and mulching.

Soil disturbance factors for the various treatments and activities and the calculations used to determine the level of detrimental soil disturbances for each proposed treatment unit are included in Appendix D. The calculated level of detrimental soil disturbance for each proposed harvest unit is consistent with the Forest Plan Standard of limiting detrimental soil disturbances to no more than 20 percent of an activity area following project implementation. Seven treatment units exceed the Regional recommendation of limiting detrimental soil disturbances to no more than 15 percent of an activity area: Units 01-S, 06-S, 10-S, 21-M, 24-S, 53-S, and 56-S. Four additional units (Units 50-S, 51-S, 58-S and 60-S) are approaching the 15 percent threshold. Unit 21-M and 56-S are of particular

[3] Surface creep is the down-slope movement of the soil surface which eventually accumulates in draws. The materials move primarily in mass through gravitational force which may be accelerated by the effect of water, wind, freezing, and thawing.

concern since portions of these treatment units have high inherent erosion hazard ratings. Site-specific implementation and effectiveness monitoring would be conducted in these units to ensure that design features and mitigation measures effectively limit erosion on areas with high inherent erosion hazard.

Total Soil Resource Commitments

Direct and Indirect Effects: No new road construction, or permanent landings and skids trails that would convert productive sites to a condition of total soil resource commitment are planned as part of the proposed action. Approximately 13 miles of road would be decommissioned using a variety of treatment methods (Appendix C). The method selected for each road segment included consideration of soils resource impacts and was selected to reduce total resource commitment over the long term. The long term anticipated outcome of these decommissioning actions would be to restore 26 acres of roads to a productive condition. The level of total resource commitments would be reduced from 1.4 percent to 1.3 percent of the project area as a result of road decommissioning.

The acres of treatment are reduced in unit 04-M, 10-M, 10-S, 13-M, 13-S, 22-M, and 53-S under this alternative. Unit 04-M and 53-S are the only two units affected and the percent of total soil resource commitments increases to 2.8 percent and 4.4 percent respectively because the size of the activity area is reduced under this alternative. Units 16-S, 17-S, 19-S are eliminated under this alternative. All treatment units except Unit 07-M comply with the Forest Plan Standard of limiting Total Soil Resource Commitments to no more than 5 percent of the defined activity area. The level of Total Soil Resource Commitments in 07-M would remain at 6.9 percent, the level resulting from existing roads that were constructed prior to 1988 when the Forest Plan was approved.

Soil Productivity

Direct and Indirect Effects: Slash retention within treatment units would provide sufficient coarse woody debris to maintain long-term soil productivity. Four to 15 tons of woody debris per acre would be retained after slash disposal treatments. Slash disposal by jackpot burning would facilitate nutrient cycling on areas that burn at low intensity; however localized areas of severely burned and hydrophobic soil can be expected where large slash accumulations are burned.

Nutrient changes often occur during combustion, including slash burning. Two differences relative to the discussion of nutrients include total site nutrient budgets versus soil-borne nutrients, and total nutrients versus available nutrients. Sites with large volumes of woody material have substantial portions of site budgets bound in organic matter, in forms unavailable to plants. When this material burns, a large amount of nutrients may remain on-site as ash, may be blown away as fly ash or washed away during overland flow, or may volatilize and leave the site in gaseous form. When bound nutrients leave the site, the site budget is decreased but the soil reservoir may remain unchanged (Owensby and Wyrill 1973 as cited by Clark 2001). Although part of a nutrient's budget may be removed, the remaining portion may be converted into a different form that is more available to plants. This is often the case with nitrogen, which volatilizes at low temperatures. When volatilization occurs, the site budget decreases but generally the ammonium form (NH_4^+), which is useable by plants, increases (Clark

2001). Increases of useable forms of nitrogen are expected as a result of low intensity burning during slash disposal.

Landform and Slope Stability

Direct and Indirect Effects: No proposed fuels reduction or vegetation treatments would occur or landtypes with high debris slide or slump hazard. Proposed treatments would occur on about 221 acres within four landtypes which have moderate to high surface creep hazard: G120bs-1, G120cs, G120cs-1, and G124r. Proposed design features, including leaving adequate coarse woody debris on-site, would result in no adverse effect to landform and slope stability in the proposed treatment units.

No fuels reduction or vegetation treatments that could contribute to landform or soil instability would occur within one-half mile of Dump Creek chasm. Two units planned for treatment in that area were eliminated from the original proposal so that instability along the chasm would not be worsened.

Alternative 4

This alternative proposes to treat 1,486 acres of lodgepole pine, Douglas-fir, and aspen by mechanically harvesting saw timber and post and pole material with tractor or cable logging systems. Associated slash disposal methods include hand or machine piling and jackpot burning. This alternative would result in 156 miles of open roads, 85 miles of closed roads, and 10 miles of seasonally closed roads. Of the 254 miles of roads in the project area, 13 miles would be decommissioned as part of this alternative.

Detrimental Soil Disturbances

Direct and Indirect Effects: The direct and indirect effects of this alternative are similar to those described for Alternatives 2 and 3.

Preliminary landing locations have been identified for each treatment unit. Tables displaying the unit number, acres of treatment, logging method, number of landings for each unit and the size of the landings are included in the project file. A map displaying the preliminary landing locations for this alternative is also included in the project file. Approximately 64 landings totaling about 11 acres would be needed to implement Alternative 4. The areal extent of landings would be less than one percent of the treated area for this alternative. All landings that are detrimentally compacted or have detrimental soil displacement will be rehabilitated by scarifying or ripping the soil to restore proper water infiltration, redistributing displaced topsoil, seeding with native species and mulching.

Soil disturbance factors for the various treatments and activities and the calculations used to determine the level of detrimental soil disturbances for each proposed treatment unit are included in Appendix D. The calculated level of detrimental soil disturbance for each proposed harvest unit is consistent with the Forest Plan Standard of limiting detrimental soil disturbances to no more than 20 percent of an activity area following project implementation. Seven treatment units exceed the Regional recommendation of limiting detrimental soil disturbances to no more than 15 percent of an activity area: Units 01-S, 06-S, 10-S, 21-M, 24-S, 53-S, and 56-S. Four additional units (Units 50-S, 51-S, 58-S and 60-S) are approaching the 15 percent threshold. Unit 21-M and 56-S are of particular concern since portions of these treatment units have high inherent erosion hazard ratings.

Site-specific implementation and effectiveness monitoring would be conducted in these units to ensure that design features and mitigation measures effectively limit erosion on areas with high inherent erosion hazard.

Total Soil Resource Commitments

Direct and Indirect Effects: No new road construction, or permanent landings and skids trails that would convert productive sites to a condition of total soil resource commitment are planned as part of the proposed action. Approximately 13 miles of road would be decommissioned using a variety of treatment methods (Appendix C). The method selected for each road segment included consideration of soils resource impacts and was selected to reduce total resource commitment over the long term. The long term anticipated outcome of these decommissioning actions would be to restore 26 acres of roads to a productive condition. The level of total resource commitments would be reduced from 1.4 percent to 1.3 percent of the project area as a result of road decommissioning.

The proposed vegetation treatments are similar to Alternative 3, except that there would be no vegetation treatments in Riparian Habitat Conservation Areas in unit 52-M, 52-S, 53-M and 53-S. The level of total soil resource commitments is the same as described for Alternative 3, except that the level of total soil resource commitments in unit 52-S would decrease to 2.25 percent, and would increase in unit 53-M and 53-S to 1.6 percent and 4.1 percent respectively under this alternative. All treatment units except Unit 07-M comply with the Forest Plan Standard of limiting Total Soil Resource Commitments to no more than 5 percent of the defined activity area. The level of Total Soil Resource Commitments in 07-M would remain at 6.9 percent, the level resulting from existing roads that were constructed prior to 1988 when the Forest Plan was approved.

Soil Productivity

Direct and Indirect Effects: Slash retention within treatment units would provide sufficient coarse woody debris to maintain long-term soil productivity. Four to 15 tons of woody debris per acre would be retained after slash disposal treatments. Slash disposal by jackpot burning would facilitate nutrient cycling on areas that burn at low intensity; however localized areas of severely burned and hydrophobic soil can be expected where large slash accumulations are burned.

Nutrient changes often occur during combustion, including slash burning. Two differences relative to the discussion of nutrients include total site nutrient budgets versus soil-borne nutrients, and total nutrients versus available nutrients. Sites with large volumes of woody material have substantial portions of site budgets bound in organic matter, in forms unavailable to plants. When this material burns, a large amount of nutrients may remain on-site as ash, may be blown away as fly ash or washed away during overland flow, or may volatilize and leave the site in gaseous form. When bound nutrients leave the site, the site budget is decreased but the soil reservoir may remain unchanged (Owensby and Wyrill 1973 as cited by Clark 2001). Although part of a nutrient's budget may be removed, the remaining portion may be converted into a different form that is more available to plants. This is often the case with nitrogen, which volatilizes at low temperatures. When volatilization occurs, the site budget decreases but generally the ammonium form (NH_4^+), which is useable by plants, increases (Clark

2001). Increases of useable forms of nitrogen are expected as a result of low intensity burning during slash disposal.

Landform and Slope Stability

Direct and Indirect Effects: No proposed fuels reduction or vegetation treatments would occur or landtypes with high debris slide or slump hazard. Proposed treatments would occur on about 221 acres within four landtypes which have moderate to high surface creep hazard: G120bs-1, G120cs, G120cs-1, and G124r. Proposed design features, including leaving adequate coarse woody debris on-site, would result in no adverse effect to landform and slope stability in the proposed treatment units.

No fuels reduction or vegetation treatments that could contribute to landform or soil instability would occur within one-half mile of Dump Creek chasm. Two units planned for treatment in that area were eliminated from the original proposal so that instability along the chasm would not be worsened.

Cumulative Effects - Alternatives 1, 2, 3 and 4

The analysis area for determining cumulative effects to soil resources is the 37,070-acre project area. This area was selected because effects to soils would occur on-site and soil resources outside of the proposed project area would not generally be affected. Past, ongoing, and future activities that could affect detrimental soil disturbances, long-term soil productivity, and landform and slope stability include timber harvest, livestock grazing, mining, wildfires, firewood cutting, noxious and invasive weed treatments, and watershed improvement projects in the Dump Creek subwatershed (see Appendix E).

The description of existing soil conditions within the analysis area reflects the impacts of past activities that have affected soil resources.

The level of cumulative detrimental soil disturbances within the project area is calculated at 2.4 percent for the No Action Alternative, 2.93 percent for Alternative 2, 2.89 percent for Alternative 3, and 2.87 percent for Alternative 4. The effects of these activities are displayed in Table 24 below.

Past timber harvesting and thinning has occurred on 5,864 acres within the analysis area (see Appendix E). Previously harvested areas within treatment units (activity areas) associated with this project were considered when determining detrimental soil disturbances from the proposed activities. The level of detrimental soil disturbances from past timber harvest from proposed treatment units is included in Appendix D.

About 1,655 acres of sagebrush and timber within the proposed project area burned during a wildfire in the summer of 2000. Burn severity mapping was conducted for the Fenster Fire BAER Report (USFS 2002). It states that 31 acres of high severity burning occurred along Wallace Creek, but no hydrophobic soils or visibly altered soils were observed. No existing areas of severely burned soils from wildfire or from management activities including prescribed burning or slash disposal have been identified within the analysis area.

Consistency with the Forest Plan

The No Action Alternative, Alternative 2 (the Proposed Action), Alternative 3, and Alternative 4 would meet Forest Plan Standards for soil resource management. Detrimental soil impacts would not exceed 20 percent of the defined activity area. The Regional guideline recommending that at least 85 percent of the activity area remain in a non-detrimentally disturbed condition would be slightly exceeded in six proposed treatment units in Alternative 2 and seven proposed treatment units in Alternatives 3 and 4. Total Resource Commitments would not exceed 5 percent of the defined activity area in all units except 7-M. The total soil resource commitment (6.9%) for unit 7-M will neither improve nor worsen as a result of this project. Long-term soil productivity would be maintained or improved by retaining appropriate levels of coarse woody debris on site. No proposed harvest units are located in areas identified as potentially unstable.

Assumptions for determining soil detrimental disturbance (DD) in Table 4 are that: (1) the cumulative effects analysis area is the 37,070-acre project area; and (2) activities that could detrimentally impact soil are ground based harvest systems which include log skidding and decking, machine piling, and jackpot burning. In addition, livestock grazing has cumulatively impacted riparian zones and soils within the analysis area (Table 4). There are approximately 300 acres of aspen treatments proposed in areas with soils exhibiting compaction and reduced productivity from livestock grazing.

The soil detrimental disturbance factors associated with tractor logging or cable yarding are 10 percent; tractor logging re-entry is 5 percent; and jackpot burning and hand piling and burning are 2 percent (Table 24).

Table 4 Soils Cumulative Effects*

Activity	No Action Alternative		Alternative 2			Alternative 3			Alternative 4		
	Acres of Prior Harvest	DD acres	Treat-ment Acres	DD acres Prior Activity	Total DD acres	Treat-ment Acres	DD acres Prior Activity	Total DD acres	Treat-ment Acres	DD acres Prior Activity	Total DD acres
Tractor/cable harvest	5864	586	1670	586	753	1553	586	741	1486	586	735
Hand pile and Burn			122		2.4	122		2.4	55		1.1
Jackpot Burn			1548		31	1431		28.6	1431		28.6
Grazing Impacts		300		300	300		300	300		300	300
Total Acres of Detrimental Disturbance		886	3523	886	1086	3106	886	1072	2972	886	1065
% of Cumulative Effects Analysis Area		2.4			2.93			2.89			2.87

***Assumptions for calculating detrimental soil disturbance (DD)**
Cumulative Effects Analysis Area = 37,070-acre project area

Soil disturbance factors for treatments and activities:

Tractor logging: 10%
Cable logging: 10%
Hand piling and burning: 2%
Jackpot burning: 2%
Tractor re-entry: 5%

Livestock grazing has impacted riparian zones within the analysis area. About 300 acres of detrimental soil disturbance is estimated within proposed aspen treatment units.

[1]Detrimental Disturbance