Gold Crown
Fuels Reduction Project

Soil Specialists' Report: Past Disturbance and Probable Impacts

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ABSTRACT
The Gold Crown Fuels Reduction Project (FRP) proposes to thin forests near Sandpoint, Idaho, to decrease the risk of catastrophic wildfire and to enhance forest health. We evaluated soils issues on a unit-by-unit basis to determine the character and extent of past soil disturbance. We also evaluated the probability of effects that proposed activities may have, as well as the cumulative effects of past, present and foreseeable actions with the proposed action. In this report, we conclude our findings by offering a set of required soil design features as part of the proposed action, as well as some recommended soil conservation practices to further minimize soil disturbance restore vitality to compromised soils.

Most of the proposed treatment units in the Project had little or no past soil disturbance. Units on which we found detectable past disturbance were usually the result of logging on moist soils.

In regard to proposed actions, our primary concerns are impacts to organic matter and compaction. On highly resilient sites, we expect little detectable soil disturbance in 20 to 40 years, *assuming* all appropriate design features are employed. Based on our findings, the project would maintain soil productivity and comply with the Idaho Panhandle NF Forest Plan (USDA 1987). The project also complies with the Region 1 Soil Quality Guidelines (USDA 1999b), as well as other pertinent laws and regulations.

INTRODUCTION
This report describes soils conditions and concerns for the Gold Crown Fuels Reduction Project. We have included:

- Analysis Methods and Scale;
- Affected Environment, including current conditions that describe the lasting effects and influence of past land management and wildfire;
- Environmental Consequences, including direct effects of proposed activities as well as the indirect effects of proposed activities. We also describe cumulative effects in light of past, present and reasonably foreseeable future events;
- "Required Design Features," which describe the best way to minimize detrimental soil disturbance. We also include "Recommended Soil Conservation Measures" and "Soil Restoration Techniques" that promote natural soil bio-physical recovery processes.

The project area encompasses approximately 573 acres of federal lands within the Idaho Panhandle National Forests in the "Gold Hill" area in Bonner County, Idaho. The general project area lies between Bottle Bay and Sagle Slough. The project is designed to reduce hazardous forest fuels in a wildland-urban interface, improve forest health, and increase the effectiveness of fire suppression activities.

REGULATORY FRAMEWORK
Laws and regulations provide direction for the management and protection of individual resources. Forest Service manuals and handbooks, forest plans, and BMPs identify the methods and guidelines that individual actions must follow to comply with the laws and

regulations. The applicable regulatory framework that provides direction for the protection of soil productivity comes from the following principal sources:

- 1987 Idaho Panhandle National Forests Forest Plan;
- FSM 2500 (WO Amendment 2500-90-2 and R1 Supplement 2500-99-1;
- National Forest Management Act of 1976 (NFMA);
- Code of Federal Regulations for Forest Planning (36 CFR 219.6);
- Multiple-Use Sustained-Yield Act of 1960 (MUSY);
- FSH 2509.18 (WO Amendment 2509.18-91-1 and R1 Supplement 2509.18-2005-1);
- Best Management and Soil and Water Conservation Practices.

See Appendix A for expanded regulatory framework.

PUBLIC COMMENTS AND CONCERNS: SOIL PRODUCTIVITY ISSUES

The following lists issues and concerns received from public comments and Soil Scientists' response to these concerns.

1. The Idaho Conservation League would like assurance that we abide by coarse woody debris standards.
    a. Response: Our proposal goes beyond standards provided by Graham et al. (1994). Our report describes in detail the value of coarse woody debris, the amount of debris currently on the land and provides guidelines to maintain this element of the forest ecosystem.
2. The Kootenai Environmental Alliance, WildWest Institute and the Lands Council would like assurance that appropriate pre-harvest soil disturbance surveys were conducted. They would like to see descriptions of the survey and results.
    a. Response: Our report details the pre-treatment surveys on a by-unit basis. Please see pertinent portions of the document.
3. The WildWest Institute and the Lands Council would like to know if the Forest Service prescribed burned any lands within the proposed treatment areas after 1990. They would like to know the circumstances of any prescribed burns and if these burns resulted in detrimental soil disturbance.
    a. Response: The last recorded major fire in this area was in 1922. Two unrecorded large fires also probably occurred in the area based on stand initiation age in 1926 and 1931. During the Gold Hill sale of 1995 three areas within the project were prescribed, broadcast burned, but although our pre-treatment soil survey found much evidence of past fire, no residual or existing detrimental soil disturbance caused by fire was found.

METHODOLOGY FOR ANALYSIS

During July 2007, two qualified soil scientists accompanied by field technicians surveyed all units with a history of soils disturbance and many units without any sign of disturbance. For the soil resource, the treatment unit serves as our "analysis area," as we do not expect activities within units to influence soil characteristics outside of unit boundaries.

On the time scale, our assessment can detect soil disturbance up to 80 years in the past. We can estimate the effects of the proposed management activities to about 60 years into the future. These estimates are based on our field experience and professional judgment.

We used Region 1 “R1” Soil Guidelines (USDA 1999) to establish the existing and potential detrimental soil disturbance. Soil disturbance is considered detrimental when long-term soil productivity is compromised. The R1 Soil Guidelines (1999) establish thresholds for compaction, displacement, rutting, erosion, and residual organic matter where detrimental soil disturbance can occur. If current conditions and estimated cumulative effects exceed 15% detrimental disturbance across a unit, long-term impacts to soil productivity are likely.

We assessed potential treatment areas to determine detrimental disturbance using two steps. First, we searched our records to determine if past soil-disturbing activities had taken place. Second, if records stated there were past management actions that may have caused soils disturbance, we assessed the site (on-the-ground) to determine the amount and character of the disturbance. Records and research sources used to determine the type and extent of historic disturbances include (unless otherwise noted files are located at the Sandpoint Ranger District office):

- aerial photos (1932 to 2002);
- timber sale records;
- historic timber sale archives;
- fire history maps (1889 to present);
- stand exam data (contained in stand files, the Timber Stand Management Record System (TSMRS), and GIS datasets);
- walk-through surveys performed in each of the proposed treatment areas by district personnel in which evidence of past activity including logging, fuel treatments, old roads, and fires, was noted (see project file). (The Forest Service forester who performed most of these walk-through exams has been trained in soil disturbance analyses.)

We used a “modified Howes” protocol that estimates the amount of detrimental disturbance within each treatment unit (Howes, 2000). We also measured:

- Percent Cover by category: Rock, Wood, Vegetation, & Litter;
- Down woody debris (tons per acre);
- Litter and duff depths;
- Percent of rock in the uppermost soil horizon;
- Depth of volcanic ash, and;
- Noted slope stability issues, erosion concerns and other soil issues.

Please see the “project file-Soils section” for unit-specific field notes.

We assessed the natural soil bio-physical resiliency of each unit to gain insight that ties current conditions to proposed treatments and cumulative effects. Understanding the complex web of processes and elements that maintain how and why the soil is resilient to disturbance is key to sustained soil productivity.

To estimate potential soil disturbance from the proposed fuels treatments, we evaluated recently thinned units that used the same treatment techniques and strategies as the proposed actions. We interviewed numerous local forest professionals to gain insight on disturbance and natural soil resiliency. We also reviewed recent research that describes issues and concerns related to volcanic ash (Page-Dumroese *et. al.* 2007).

AFFECTED ENVIRONMENT / EXISTING CONDITION

The Gold Crown FRP Project Area encompasses forest lands that vary greatly in elevation, aspect, slope, forest type, disturbance history, and resilience to disturbance. The last large stand-replacing fire on record occurred in 1922 and burned over 1,300 acres in the area so the stands are between 77 and 82 years old. In addition, walk-through exams indicate that there was at least one other large fire on northeastern and eastern aspects in the project area between 1926 and 1931. Most of the project area was affected by these fires, though a few wet areas are the exception. The southern and western aspects of this area are dominated by shrubs, grasses, scattered timber and rock outcrops. The northern and eastern slopes are dominated by dense forest stands with many draws and riparian areas throughout.

The parent geology (Map 6, Appendix C) consists of glaciated Precambrian metasedimentary Belt rocks of the Prichard Formation. Glaciated granitics and some alluvial deposits are present within the project area as well, but not in any of the proposed treatment units. Landscape morphology is primarily composed of straight to convex glaciated ridges and mountain sideslopes with some scoured sideslopes. Compacted glacial tills and rock outcrops can occur in these soils. A minor amount of floodplains, meadows, stream terraces, and scree slopes are scattered throughout individual activity units.

With respect to soils, most of the proposed treatment units are similar in one aspect: the topmost mineral soil horizon is volcanic ash. Mount Mazama, now Crater Lake, Oregon, experienced a cataclysmic pyroclastic eruption about 7,000 years ago. In the "Gold Hill" region, the ash is typically between 6 and 14 inches in depth. The upper most ash layer in this area was deposited in 1980 from Mt. St. Helens. The "ash cap" imparts both benefits and vulnerabilities to forest soil characteristics. Volcanic ash has a high water-holding capacity and provides an excellent germination substrate for many native plant species. Unfortunately, ash is extremely vulnerable to compaction, displacement and (when laid bare by disturbance) erosion. All soils are more sensitive to compaction disturbance when moist, but ash-capped soils are especially sensitive when moist.

Volcanic ash soils do not provide or hold plant-available nutrients well. For this reason, the organic element of the soil in the Gold Crown region is especially important.

Under the objectives outlined in the National Forest Management Act, the U.S. Forest Service has assembled the North American Long-Term Soil Productivity research program (LTSP). The LTSP has focused its attention on *two* soil properties that are most influenced by timber harvesting and most related to forest integrity within the constraints of climate and topography: (1) **soil organic matter**, and; (2) **soil porosity** (Powers et al. 1998). Soil nutrients are also an important component to soil productivity.

Organic matter and soil porosity are also the primary soil concerns for the Gold Crown FRP. Soil organic matter can be influenced by fire, silvicultural prescriptions, timber harvests, and decomposition and accumulation rates. Soil porosity is most influenced by mechanical compaction and bio-physical resiliency.

Other soil factors analyzed or discussed in this report include: biophysical resiliency, nutrient issues, and landtype hazard ratings including mass failure potential, landtype sensitivity and surface erosion potential.

Soil Organic Matter

Although often overlooked in forest management plans, the importance of soil organic matter cannot be overstated (Okinarian 1996, Jurgensen *et al*. 1997). This organic component contains a large reserve of nutrients and carbon, and it is dynamically alive with microbial activity. The character of forest soil organic matter influences many critical ecosystem processes, such as the formation of soil structure, which in turn influences soil gas exchange, soil water infiltration rates and soil water-holding capacity. Soil organic matter is also the primary location of nutrient recycling and humus formation, which enhances soil cation exchange capacity and overall fertility.

These processes have direct and tremendous effect on site productivity and sustainability. Fortunately, organic matter is the one component of the soil resource that, if managed correctly, can actually be improved by human activity. Manipulation of the organic constituents of the soil may be the only practical tool available for mitigating effects of harvesting systems that remove standing trees and dead and down trees, or cause extensive soil disturbance. Of the many organic materials incorporated in a forest soil, the woody component is in many ways the most important. To protect the sustainable productivity of the forest soil, a continuous supply of organic materials must be provided, particularly in harsh environments (Harvey *et al*. 1987). A clear understanding of fungal processes and the creation of soil organic matter are essential for forest management and forest soil restoration.

As mentioned, ash soils in the Gold Hill region lack nutrients and nutrient-holding capacity relative to other soil types, making stewardship of the organic horizon a top priority.

A small amount of work has been done in an attempt to predict fuel loading while considering fuel succession. Fuel succession refers to the change in fuel properties and embodies the concepts of both accumulation and decay (Brown and See 1981). Fuel succession is the change in the fuel complex over the long term, including changes in loading, size distribution, availability to burn, and live-to-dead fuel ratios. These processes are the net result of the counteracting processes of accumulation and decomposition (Miller 2000). The concept of fuel succession is intriguing and may prove quite useful when attempting to predict real verses perceived fuel loading and fire hazard issues balanced against the needs of the forest.

Soil Wood

Brown Cubical Rot (BCR): No discussion about forest woody debris and biological activity would be complete without promoting the values of brown cubical rot, and recommendations that may increase the amount of the product of this unique decomposition process across the landscape. BCR is the result of numerous endemic, wood-infecting fungi, many of which are stem and heartwood diseases of native conifers.

Residue left after advanced brown-rot decay is a brown, crumbly mass composed largely of lignin. In healthy forest ecosystems, especially coniferous forests, the upper-most soil horizon contains a significant portion of brown-rotted wood residues. The sponge-like properties of advanced brown-rotted wood act as a moisture and nutrient sink. Because of the high lignin concentrations, and low carbohydrate rates, it persists in the forest for a long time (Blanchette 1995).

The lignin product of brown rot is tremendously important in the forests of the West. Since brown rot typically affects only heart wood, it is important that large trees are allowed to die and decompose naturally in the woods. For example, a larch 36 inches in diameter may possess 24 inches of heart wood. This in turn decomposes to a 16-inch zone of brown cubical residue, often referred to as soil wood. Early logging techniques that bulldozed forest debris into piles and then burned the organics significantly reduced the occurrence of soil wood in our forests. Soil wood possesses one key characteristic that makes it important: the ability to hold water. This high water-holding capacity provides:

- Plant-available water, especially during the driest months;
- Excellent underground habitat for all types of soil biological activity;
- Appropriate conditions that cause a hub of mycorrhizae fungi activity.

When a site loses woody soil components, the replacement process may take from 100 to 300 years (Harvey *et al.* 1981).

To ensure sustained forest use and protect ecosystem integrity, it is imperative that land managers understand two concepts in regard to the fungal resource. First, the role of fungi is essential for the continuance of many ecosystem processes. Second, with proper awareness and skill, forest managers can greatly influence fungal processes and potential benefits.

Wood decay fungi in the coniferous forest ecosystem have three major roles:

- breaking down plant residues and recycling carbon to the soil or the atmosphere;
- releasing mineral nutrients from plant residues and making the nutrients available to living organisms, and;
- producing the physical character of the soil matrix.

The outcomes of these processes promote soil water infiltration rates, soil water-holding capacity, cation exchange capacity, nutrient availability, nitrogen fixing activity, and habitat for mycorrhizae associations, to name a few.

Managers can influence fungal processes by considering the effects of silvicultural, harvesting, and slash disposal activities. Silvicultural plans that promote fungal processes will prescribe harvests that preserve a cool, moist microclimate and provide for a continuous source of large woody debris for use by fungi. Harvest techniques should be light on the land, disturbing as little soil as possible. Slash management techniques should emphasize leaving as much debris as is appropriate on site.

Soil Porosity

Soil porosity refers to the amount and character of void space within the soil. In a "typical" soil approximately 50% of the soil volume is void space. Pore space is lost primarily through mechanical compaction. Two fundamental processes are negatively impacted by compromised soil pore space:

- Gas exchange;
- Soil water infiltration rates.

Gas Exchange

Soil oxygen is fundamental to all soil biologic activity. Roots, soil fauna, and fungi all respire, using oxygen while releasing carbon dioxide. When gas exchange is compromised, biologic activity is also compromised. Maintaining appropriate soil biologic activity is paramount when considering long-term forest vitality.

Soil Water Infiltration Rates

Severely compacted soils do not allow appropriate water infiltration, leading to overland flow and associated erosion, sediment delivery, spring flooding, and low summer flows. Some recent advances in logging technology and mechanization have exacerbated the problem, as feller bunchers must travel to each tree and slash is often piled with excavator type, tracked grapple equipment. Skid trails are the longest lasting detrimental disturbance, where many machines travel over the same route. Again, activities on moist soils are especially damaging. Work on dry or frozen soils maintains much more of a soil's natural ability to quickly restore pore spaces.

Soil Bio-physical Resiliency

Though ash-capped soils are sensitive to disturbance, we also found most soils in the Gold Crown FRP area are relatively resilient. For example, we observed that soil pore space is naturally restored after mechanized disturbance from 60 to 80 years on main skid routes. Where resiliency is high and soil compaction moderate, we observed natural pore space restoration from 40 to 60 years. For new activities where all appropriate design features and techniques are employed, we expect naturally restored soil pore space to occur between 5 and 40 years.

Soil pore space is restored through natural aggregation processes, the result of two primary processes: 1) biologic activity; and 2) freeze-thaw events, or wet-dry events.

Understanding the factors that preserve, maintain, or improve natural bio-physical resiliency is the key to understanding the relationship between existing conditions and probable environmental impacts from forest treatments.

One of the most important skills a land manager can acquire is the ability to predict how much abuse a soil can experience before crossing the threshold where natural aggregation processes are significantly compromised. For example, a soil is relatively resilient after moderate tractor logging and very resilient after fire; but the combination of these two disturbances has a synergistic effect that can negatively influence natural restorative processes.

Unfortunately, recognizing and understanding where this threshold lies is difficult. Many factors create a complex web of interrelationships that impart resiliency, or the lack thereof, to the soil resource. We will discuss these factors later in the "Minimizing soil impacts" section.

Nutrient Issues

The Intermountain Forest Tree Nutrition Cooperative (IFTNC) has concerns that potassium might be limited on some types of parent material, specifically the belt meta-sediments. Under most natural circumstances, potassium returns to the soil when the tree dies. Unlike many other soil nutrients, potassium is derived primarily from the underlying geology, which, within the Gold Crown FRP proposed units, is derived from glaciated belt parent materials.

The IFTNC continues to research potassium contents within tree species and different rock types in order to establish specific minimum thresholds for retention and effects of potassium on tree growth and resistance to root diseases (Mika 2005, Shaw 2005, Garrison-Johnston *et al*. 2007). Until these minimum thresholds are developed through research, the Idaho Panhandle National Forests are using management recommendations from the IFTNC as a guideline for maintaining sufficient potassium on a site. These measures have been incorporated into the "Required Design Features."

Whole-tree yarding and removal of treetops can lead to the direct loss of potassium (Morris and Miller 1994). On some sites, 45 percent of the available potassium is detained in trees, with the remainder being held in subordinate vegetation, forest floor, and soil pools. Within the trees, about 85 percent of the potassium is held in the branches, twigs, and foliage (Garrison and Moore 1998, Moore *et al*. 2004). It is therefore vital to recycle as many nutrients as possible before removal, which can be accomplished by overwintering small-scale debris to leach out potassium and other nutrients (Baker *et al.* 1989, Barber and Van Lear 1984, Edmonds 1987, Garrison and Moore 1998, Laskowski *et al*. 1995, and Palviainen *et al*. 2004). In addition to leaving branches in the forest for a time, promoting a healthy soil organic component is perhaps the best way to maintain and enhance plant-available nutrients.

Landtypes and Hazard Ratings

Fifteen landtypes are mapped out in the Gold Crown FRP project area (Map 5, Appendix C), and six of those are in harvest units identified in the proposed action. Descriptions of each landtype, detailed acreages, and maps displaying landtypes and hazards are contained in the project file and the map appendix (Appendix C, Maps 1-5). Here we have summarized acreages of hazard ratings for proposed units, and listed them in subcategories for mass failure, surface erosion, landtype sensitivity, and soil productivity. These are rated as low, moderate, or high for each landtype (Table 1). None of the hazard ratings for proposed units are classified as high or severe.

Table 1. Summary of landtype hazards (in acres) associated with harvest activities in the proposed units.

Mass Failure Potential			*Landtype Sensitivity*			*Surface Erosion Potential*			*Soil Productivity*			
L	*M*	*H*	*L*	*M*	*H*	*L*	*M*	*H*	*L*	*LM*	*M*	*MH*
174	*399*	*0*	*174*	*399*	*0*	*174*	*399*	*0*	*81*	*0*	*492*	*0*

L – Low; M – Moderate; H – High; MH – Moderately High

Mass Failure Potential
Removal of forest canopy and cover from either clearcutting or wildland fire increases landslide occurrence (Gray and Megahan 1981, Megahan et al. 1978). This is primarily due to root decay, soil disturbance, increased snow accumulation and altered melting rates, and soil water increases from reduced interception and transpiration.

Mass failures detrimentally disturb soils because organic matter, the productive ash layer, and even subsurface layers of the soil can be carried down slope during a failure. Thirty percent of landtypes in the activity area have low mass failure potential; 70% have a moderate mass failure potential; and no landtypes in any units have a high mass failure potential.

Little research has been conducted to determine if partial cutting affects landslide rates. Megahan et al. (1978) found that landslide occurrence increased only slightly when overstory canopy was reduced from 100% to 11%, but increased dramatically when canopy closure went below 11%. They also found that crown cover from shrubs affected landslide occurrence after 80 percent crown removal and indicated that landslide occurrence is more sensitive to shrub than tree crown removal.

Landtype Sensitivity
Landtype sensitivity is the relative probability of eroded soil reaching a stream channel and becoming sediment. The majority (70%) of the area has moderate landtype sensitivity ratings. Thirty percent of the landtypes within the proposed units have low landtype sensitivity ratings, and no landtypes within the units have high sensitivity ratings.

As part of project planning, all drainage courses and riparian zones have a designated buffer zone that will not be entered by any proposed harvest activities, as recommended by Inland Native Fish Strategy (INFS). With established buffer zones, the potential sediment increases and delivery from fuel or timber management work is minimal.

Roads are considered a potential source for sediment delivery and are analyzed in detail in the Specialist's Report for Hydrology.

Surface Erosion Potential
Surface erosion potential is a rating of the relative susceptibility of exposed soils to sheet and rill erosion. In the activity areas, surface erosion hazard ranges from 30% (low), to 70% (moderate). None of the activity areas have a high surface erosion hazard rating.

The potential for soil erosion concerns is not so much associated with harvest treatments as with existing roads (Cacek 1989). The dominant processes in roaded areas are surface erosion from bare soil areas of roads, including the cutslope, fillslope, and travelway.

Revegetation of cut slopes and fill slopes is often difficult due to lack of soil moisture, organic material, low productivity potential, and desiccation of seeds and seedlings, especially on south-facing slopes. On moist slopes, revegetation efforts are more successful since erosion of road cut slopes and fill slopes is generally lower.

Road erosion and sediment yield usually decline after construction (Jones 2000, Switalski *et al*. 2004) but can provide a chronic, long-term source of sediment to streams.

Periodic large pulses of erosion may occur during intense water yield and overland flow events in interaction with road drainage systems. Roads and their associated impacts are analyzed in detail in the Specialist's Report on Hydrology.

Soil productivity

Soil productivity, the annual ability of the soil to produce plant mass, is low on 14% and moderate on 86% of the proposed action activity areas. Table 2 displays acres within units where soils were classified with low soil productivity. Small portions of units 4, 7, and 21 are classified with low soil productivity, almost all of unit 1, 25, and 31 and all of unit 10 have been classified with low soil productivity. Extra caution should be employed in making sure organic matter is not disturbed within these units to ensure maximum soil productivity following treatments.

Table 2. Acres within units of low soil productivity

Unit	Acres
1	10.12
4	7.67
7	1.43
10	36.07
21	1.15
25	16.64
31	8.19
Total	81.27

Existing Disturbance

As mentioned, the proposed treatment units display a wide variety of existing conditions. Table 3 shows the relative acreage of the soil conditions and Table 4 displays the current conditions by unit in the project area. Units 16 and 28, were not formally surveyed, but the forester (who has been trained in soil analysis techniques) walked through these units and determined there was no detrimental soil disturbance within these proposed areas. Units 16 and 29 were not formally surveyed by the soil survey crew either; however, the forester identified some portions of unit 29 and unit 1 incurred minor disturbance from the 1995 Gold Hill Timber Sale. Based upon on-site evaluations and district timber sale files, that project implemented a light thinning harvest, individual tree marking within approximately half of the current proposed unit 29 and two-thirds of the current proposed unit 1. This disturbance was estimated to be equivalent to that formally surveyed in proposed unit 10 (resulting from the same disturbance, silvicultural prescriptions, and harvest type.) As a result, 2.2% detrimental disturbance was calculated for both of these two units.

Here we attempt to summarize current soil characteristics for three basic situations:

- Undisturbed and Slightly Disturbed Units (less than 6% detrimental disturbance)
- Moderately Disturbed Units (6 - 10% detrimental disturbance)
- Highly Disturbed Units (Greater than 10% detrimental disturbance)

Table 3. Acres of soil conditions found within surveyed units.

Disturbance Category	Acres
Undisturbed or slightly disturbed (0-5.99%)	542

Disturbance Category	Acres
Moderately disturbed (6-9.99%)	31
Highly disturbed (10%+)	0

<u>Undisturbed and Slightly Disturbed Units (less than 6% detrimental disturbance)</u>
Most of these units experienced at least one burn in the early 1900s. Since that time the litter layer and soil organic matter has been developing but is not yet mature. There are very few signs of timber harvest or other soil-damaging activities. Generally these units have many small- to medium-sized trees and are currently self-thinning, which leaves needed woody debris on the forest floor. These forests generally have a high degree of natural biologic resiliency and appropriate ecologic trends.

<u>Moderately Disturbed Units (6 - 10% detrimental disturbance)</u>
Two units have moderate current soil disturbance. Unit 11 and unit 22 (Table 3) have more recent harvest activity and skid trails present but sites are recovering and are resilient. Cumulative effects will be discussed below.

<u>Highly Disturbed Units (Greater than 10% detrimental disturbance)</u>
There are no highly disturbed units within the proposed treatment area.

Table 4. Current conditions by unit at Gold Crown

Unit #	Down Woody Debris (T/Ac.)	Coarse Fragments	Total Organics (cm)	Existing Detrimental Disturbance
1	--	--	--	2%
2	10	20-30%	3.0	2%
3	9	10-30%	3.0	2%
4	6	5-30%	1.8	2%
5	10	20-30%	2.8	0%
6	6	5-30%	1.9	2%
7	12	10-20%	4.0	0%
8a	12	10-20%	4.0	0%
8b	12	10-20%	4.0	0%
8c	12	10-20%	4.0	0%
8d	12	10-20%	4.0	0%
9	6	5-30%	1.9	2%
10	6	5-30%	1.9	2%
11	9	15%	3.0	9%
12a	5	35%	2.0	0%
12b	5	35%	2.0	0%
14	5	35%	2.0	0%
15	12	<5%	2.9	0%
16	--	--	--	0%
17	15	10-20%	3.0	1%
18	15	10-20%	3.0	1%
19	17	5-10%	1.6	2%
20	10	5-10%	3.9	0%
21	17	<5%	3.9	0%
22	10	< 5%	1.8	7%

Unit #	Down Woody Debris (T/Ac.)	Coarse Fragments	Total Organics (cm)	Existing Detrimental Disturbance
23	17	5-10%	1.6	2%
25	9	5-10%	3.3	0%
26	15	5%	2.4	0%
27	9	5-25%	2.9	2%
28	--	--	--	0%
29	--	--	--	2%
30	6	5-30%	1.9	2%
31	11	10-20%	4.0	0%
32	15	5%	2.4	0%
33	22	<5%	3.8	0%
34	7	5-10%	2.5	0%

Down Woody Debris & Soil Wood

Woody debris can be an indicator of site bio-physical resiliency and overall forest health. Units 3, 4, 6, 9, 10, 11, 12a, 12b, 14, 22, 30, and 34 do not have the recommended amount of woody debris (Graham *et. al*. 1994). Graham *et al*. (1994) suggest 7-14 TPA of down woody debris on dry forest types in this area and about 16-33 TPA on moist forest types. We also use soil wood, which is the decomposition product of brown cubical rot, as one of the indicators of forest ecological integrity. Most of the units have sufficient amounts of soil wood; however, due to the average age and size classes of trees in the project area, large trees necessary for future soil wood contributions are uncommon.

Coarse Fragments

The percent of coarse fragments is a measure of rock content in the surface six inches of mineral soil. Rock content is an excellent indicator of the effect of compaction on a specific soil type. Rock content over 35% will greatly reduce the effect of mechanical compaction. As Table 1 indicates, rock content for many of the units is below 35%, meaning that these soils are especially vulnerable to compaction.

Total Organics

This is a measure of the total depth of the combined litter and duff organic horizons. This measure is another indicator of bio-physical resiliency. The depth and character of the organic horizon influences soil structure, moisture-holding capacity, nutrient cycling, pH, and soil temperature. The organic horizon also provides insight into decomposition and organic accumulation rates.

Organic horizon depths in the range of 3 to 5 centimeters are typical for this forest type. As our data indicate, the litter and duff layers are generally a bit shallow. This can be caused by a number of reasons, such as an imbalance between decomposition and accumulation rates, or serve as evidence of a developing litter layer after a disturbance. In this case, since charcoal is present in most of the units, we know that the litter layer is still developing after the last wildfires.

ENVIRONMENTAL CONSEQUENCES

Alternative Action A - No action

Direct and Indirect Effects

For the undisturbed to moderately disturbed sites within the project area, the "no action" alternative will have no direct influences on forest soils.

Indirectly, the "no action" alternative will allow developing litter layers to mature. Untreated, self-thinning stands will continue to contribute woody debris to the forest floor, allowing decomposition to continue and adding needed organics and soil wood to the soil profile.

Given the absence of fire over numerous decades and increased fuel loads in most of the project area, the chance of an intense wildfire occurring could be enhanced if an ignition starts in an untreated area during extreme dry weather conditions (Heyerdahl *et al*. 2007). The proposed vegetation and fuels treatment in the project area would not necessarily prevent wildfires from occurring, but would increase the ability to suppress such a fire should ignition occur in treated areas (Maurer 2007).

The probability of a high-severity fire is not certain to occur within the project area during a given timeframe. However, when a fire breaks out, the chances for high-severity fire effects on soils can be much higher in untreated areas with excessively heavy fuel loads compared to those that have successfully completed treatment, including post-harvest logging slash (Certini 2005, Cram *et al*. 2006, Graham *et al*. 2004, Gorman 2003, Keane *et al.* 2002).

The proposed vegetation and fuel treatments would reduce the chance that a wildfire could have as severe of an effect on the soils and surrounding private property in treated areas as it could in untreated areas because there would be a reduction in the tons per acre of dead and dying fuels on treated sites.

The no action alternative could indirectly result in a higher risk of a high-intensity wildfire. The occurrence of a high-intensity wildfire would have an increased potential for impacts to soils and soil productivity in severely burned areas, especially since the risk of soil erosion increases proportionally with fire intensity (Megahan 1990). Other potential detrimental effects could include the potential loss of organics, loss of nutrients, and a reduction of water infiltration (Wells *et al*. 1979). Burns that create very high soil-surface temperatures, particularly when soil moisture content is low, result in an almost complete loss of soil microbial populations, woody debris, and the protective duff and litter layer over mineral soil (Hungerford *et al*. 1991, Neary *et al*. 2005). Nutrients stored in the organic layer (such as potassium and nitrogen) can also be lost or reduced through volatilization and as fly ash (DeBano 1991, Amaranthus *et. al*. 1989).

Fire-induced soil hydrophobicity is presumed to be a primary cause of the observed post-fire increases in runoff and erosion from forested watersheds (Huffman *et al*. 2001). Though hydrophobicity is a naturally occurring phenomenon that can be found on the mineral soil surface, it is greatly amplified by increased burn severity (Doerr *et al.* 2000; Huffman *et al*. 2001, Neary *et al*. 2005).

Soil hydrophobicity usually returns to pre-burn conditions in no more than six years (DeBano 1981). Dyrness (1976) and other studies have documented a much more rapid recovery of one to three years (Huffman *et al*. 2001). The persistence of a hydrophobic layer will depend on the strength and extent of hydrophobic chemicals after burning and the many physical and biological factors that can aid in breakdown (DeBano 1981). This variability means that post-fire impacts on watershed conditions are difficult to predict and to quantify.

If hydrophobic soils result from a severe, high-temperature fire, moderate to high surface erosion could occur. In addition, the potential for mass failures would be low to moderate because of the overall landtype characteristics within the project area; however, localized slope movement could be possible, especially along roads on steeper mountain slopes.

Cumulative Effects

Furthermore, we can assume that within this project area, which is entirely within the wildland-urban interface, one of the foreseeable, future actions is wildfire suppression. Land management agencies and those with firefighting responsibilities in the area will have to continue to fight wildfires in the area to protect homes, private property, and public infrastructure. Additionally, natural ecological processes, including forest stand succession and tree mortality will also continue to occur. When the indirect effects of the no-action alternative are added cumulatively to the future wildfire suppression and natural forest ecological processes, we can predict there will be additional accumulations of down, woody debris (or fuels) and a higher fire hazard prior to the next stand-replacing fire event. In this case, the potential detrimental indirect effects to soils (listed above) may be increased. These potential cumulative effects could include an increased potential for loss of organics, loss of nutrients, reduction in water infiltration, loss of soil microbial populations, loss of woody debris, loss of protective duff and litter layer over the mineral soil horizons, potential increase in risk of hydrophobicity resulting from fire, and associated potential increases in risk of post-fire runoff and erosion.

Alternative Action B - Proposed action

The proposed action would meet forest plan standards and regional soil quality guidelines. Adverse effects from the proposed activities would be primarily from 2.2 miles of system roadbuilding, 685 feet of temporary road building, and tractor based timber harvest over 264 acres. Prior impacts that demand additional mitigation measures to meet soil quality standards exist on 27 acres total, for Units 11 and 22. These units have existing soil disturbance at 9% and 7%, respectively, from prior log skidding and log landings. To minimize negative impacts and reduce risk for adverse cumulative effects to these units, harvest would be limited to cut to length logging systems, which operate on a slash mat. Furthermore, machine operation would be restricted to skid trails only.

Approximately 212 acres have moderate risk for severe burn effects where skyline or helicopter yarding is followed by prescribed, broadcast burning of slash. Steep slopes and high fuel loads create conditions at high risk for severe burn. Therefore, to minimize potential detrimental impacts, all prescribed burning will be accomplished when soil moisture is >25%.

Road reconstruction activities (of existing, barriered road) would not adversely affect soils because the reconstruction would effectively improve drainage and would not alter the quantity of land taken out of the productive land base. Skyline (238 acres) yarding, helicopter yarding (65 acres) and hand thinning (6 acres) would have minimal adverse impacts on soils.

Direct Effects

Potential adverse soil disturbance is from log harvesting, yarding and road building. Effects displayed and analyzed in this section include:

- Compaction;
- Rutting & displacement;
- Severely burned soils;
- Degradation of the litter layer and soil organic matter caused by increased decomposition rates and lack of appropriate annual litter contributions and/or destruction by prescribed fire;
- Lack of large woody debris;

Timber harvest activities

Years of field observations have shown us that past effects from logging are detectable up to 80 or more years. Proposed activities use techniques that maintain or promote natural soil bio-physical resiliency. The effect of proposed activities should be relatively short compared to techniques used in the past. If all natural elements and processes remain intact, we can expect soil impacts to be nearly undetectable within 20 to 40 years.

Proposed activities' effects on the soil can be minimized by using techniques and restoration strategies outlined later in this report. Proposed treatments and total acres by treatment in the project area are displayed in Table 5. The amount of expected detrimental disturbance will vary greatly with proposed treatments. Detrimental disturbance levels were estimated using Niehoff (2002) as well as ground truthing, and take into account best management practices described in Niehoff (2002). Table 5 illustrates expected effects based on a variety of proposed treatments and scheduled season.

Table 5. Methods of fuels treatment, acres of harvest, and predicted additional disturbance (based on Niehoff (2002) and on-the-ground observations) for the proposed action. Predicted disturbance values assume no re-use of existing skid trails or landings. (Such re-use has been determined to be feasible within some units and is calculated in Table 6.)

Harvest System/Fuel Treatment	Acres	Predicted Additional Detrimental Disturbance (Niehoff, 2002)
Hand Thin/Slash, Hand pile/Burn	6	0%*
Helicopter harvest; Broadcast burn	23	0-2%
Helicopter harvest; Yard unmerchantable	42	0%
Skyline harvest; Broadcast burn	189	0-2%
Skyline harvest; Excavator pile corridors	36	5%*
Skyline harvest; No slash treatment	13	0%
Mechanical harvest; Broadcast burn	50	6-13%

Harvest System/Fuel Treatment	Acres	Predicted Additional Detrimental Disturbance (Niehoff, 2002)
Mechanical harvest; Grapple pile and burn	171	8-11%
Harvester (Cut-to-Length)/forwarder yard; Operate on slash mat; grapple pile and burn (Units 11 & 22)	32	11%
Tractor Swing; Grapple pile and burn	11	11%
Total Acres	**573**	

* values based on our on-the-ground observations

Ground-based Logging

As mentioned earlier, units 11 and 22 currently have existing soil disturbance of 9% and 7% respectively. Approximately half of the existing skid trails and landings within these units will be reused. Required design features for these units include using cut to length logging systems, which operate off of a slash mat, and restricting machines to skid trails. Such design features will ensure that detrimental soil disturbance will not exceed 15% (Table 6) (see Cumulative Effects Analysis section, p. 20-25). Appropriate ground-based logging alone leaves the forest with a high degree of natural biological resiliency. The added effects of an understory burn vary widely, but generally increase disturbance when performed immediately following harvest. Winter work on frozen soils, on an appropriate snow pack, or grapple piling on a slash mat will reduce the total amount of new detrimental disturbance. Logging followed by a "hot" or intense prescribed burn (when soil moisture is <25%) has a synergistic effect on forest soils which can significantly lower natural biologic resiliency and increases long-term detrimental disturbance. Therefore, required design features include performing prescribed burning only when soil moistures are >25%.

Skyline and Helicopter Logging/Hand Thinning

Biologic resiliency remains intact on skyline units (Table 6), as it is the combination of compaction and burning that causes significant long-term soil damage. Skyline yarding corridors where one end of a log drags over the surface can cause soil displacement, scraping off the organic layer and exposing the mineral soil to erosion. Again broadcast burning after skyline logging or helicopter logging poses greater risk to the soil than harvesting alone, as fuel loads are typically high in this area and some slopes are quite steep.

Helicopter logging has the least impact on the soil. Helicopter logging preserves biologic resiliency, so the effects of a moderately cool burn on soils will be relatively short in duration.

Special hazardous fuels harvest on rock outcrops

On these units (5 and 33, Table 6) the Forest Service plans to remove all small trees, leaving only the large, relic trees. The agency plans to introduce prescribed fire on a 10 to 30 year interval. In our experience in this area, low-intensity, frequent fires of this nature, will not add detrimental soil disturbance within units.

Road building activities

New system road construction is planned for 2.2 miles in the vicinity of or adjacent to units 2 and 3, 8a-8d, unit 17, and unit 29. (see Map 1). In addition, new, temporary road construction is necessary to access unit 34. This unit requires approximately 685 feet of temporary road construction, although only about 100 feet of road will be within the unit.

Units 2 and 3 will have new system road construction bisecting them, totaling 0.3 and 0.4 miles respectively and resulting in roughly 0.9 and 1.2 acres construction-related disturbance. These new, system roads are considered dedicated uses and thus this acreage is removed from the sustainable land base (USDA 1999b).

Unit 34 is a six acre unit with about 100 feet temporary road planned within the analysis activity area. Thus, disturbance from road building is 1% of the unit area. Temporary roads are not dedicated uses, and thus still retained within the sustainable land base. Rehabilitation will be used to recover this area as soon as harvest operations finish. Recovery will likely be slower than other harvest related disturbance given the high traffic.

Road construction results in the highest disturbance to soils with complete removal of soils and interception of slope hydrology. The system roads are considered a designated use and will be maintained for adequate drainage to minimize indirect effects of soil loss along barren fill slopes.

Current temporary road construction practices address the potential negative impacts with stringent rehabilitation efforts. Temporary road templates are restored to contour. Topsoil is conserved and replaced where possible to further recovery. Road fill is covered in slash for biological and site amelioration.

Hydrological recovery is expected within the first 10 years with soil infiltration rates lower than natural forest rates (Luce 1997, Foltz and Maillard 2003). For the long term, infiltration rates improve over time as freeze/thaw and plant roots improve soil porosity though rates would remain lower than adjacent natural forest soil (Switalski *et al*. 2004). Soil biological function restores as forest floor and native plant communities returns. Moist areas in the lower to middle portion of the watershed have higher restoration potential. Also, most of the project area has a northeast aspect, and thus cool and wet conditions that promote vegetation growth.

Indirect Effects

Many indirect effects are possible if soils are detrimentally-disturbed as a result of the proposed action. Such indirect effects could include:

- Compaction can indirectly lead to decreased water infiltration rates, leading to increased overland flow and associated erosion and sediment delivery to stream. Increased overland flow also increases intensity of spring flooding, degrading stream morphological integrity and low summer flows.
- Compaction indirectly leads to decreased gas exchange, which in turn degrades sub-surface biological activity and above-ground forest vitality.
- Rutting and displacement cause the same indirect effects as compaction and also channel water in an inappropriate fashion, increasing erosion potential.
- Severely burned soils (when soil moisture is <25%) can indirectly influence many forest elements and processes. Expect possible weed incursions, changes in

hydrology as described above, and decreased biologic activity and associated events.

- Loss of organic matter will decrease natural resiliency to disturbance, decrease nutrient cycling and availability, decrease soil water and nutrient-holding capacity, decrease aggregate formation and all benefits associated with aggregation.
- Lack of large woody debris will influence the forest soil in a similar way as does the loss of organic matter.

Harvest operations remove biomass and can remove site organic matter, thus affecting nutrient cycling. Generally, nutrient losses are proportional to the volume of biomass removed from a site. Nutrients are lost during harvesting by removing the stored nutrients in trees, and additional nutrients are lost if the litter layer and woody debris are removed. Yarding unmerchantable materials, which extracts larger amounts of biomass, especially nutrient-rich foliage, compared to conventional sawlog, cut-to-length or thinning operations, removes a larger amount of the nutrients from the site. The exact amount of nutrients lost from a particular site will vary with forest types and particular site conditions (Grier *et al*. 1989). The amount of nutrients present in the trees will also vary with stand age and development of the humus layer (Grier *et al*. 1989). Moreover, the greater the proportion of nutrients stored in trees, the greater the potential for site degradation and declines in productivity after harvesting operations. The data suggest that nutrient losses from yarding unmerchantable materials are considerably greater when compared to conventional sawlog harvesting for all nutrients.

For example, a direct effect of harvesting on all sites would include removal within each tree bole (and bark) about 22 percent of the potassium that is contained within a tree (Garrison-Johnston *et al*. 2004). This may have an indirect effect on some plants that remain in the stand. The commercial removal of Douglas fir, grand fir, western cedar, and hemlock in association with leaving western larch would allow the release of stored foliar potassium as a beneficial nutrient for uptake by western larch (Garrison-Johnston *et al.* 2007, Garrison and Moore 1998). Western larch is a more potassium-efficient species and would remain throughout those units where it already is part of the stand component. Measuring the effects of on-site productivity, however, cannot be done with certainty until more research information becomes available. At this time, management recommendations from the IFTNC are used as guidelines for maintaining sufficient potassium on a site.

Prescribed fire can increase available nitrogen for one to two years following (Choromanska and DeLuca 2002). Burning slash piles could create extremely high temperatures in concentrated areas that could lead to volatilization of nitrogen, loss of phosphorus and potassium (DeBano 1981). If litter layers and organic matter are kept intact throughout the rest of the stand, nutrient losses would be minimal from burning slash and would be localized. Nitrogen-fixing plants can colonize sites following fire and help restore N in the ecosystem (Newland and DeLuca 2000, Jurgensen *et. al*. 1997). Following fire, soil erosion can increase, which could also reduce the nutrient pool (Megahan 1990). Generally, if plants colonize sites following fire, nutrient levels can reach pre-fire levels quickly (Certini 2005). Charcoal deposited following fire also adds carbon to the soil (DeLuca and Aplet 2008).

Indirect effects of soil-nutrient loss could include reduced growth and yield and increased susceptibility to pathogens, such as root disease (Garrison and Moore 1998, Garrison-Johnston 2003) and insect infestation (Garrison-Johnston *et al*. 2003 and 2004). Precipitation (Stark 1979) and weathering of rocks will continue to make additional nutrients available on site. Annual needle, leaf, and twig fall, forbs, and shrub mortality will continue to recycle nutrients as well.

A direct effect of the proposed action may be the decreased fire risk and increased forest health, which could indirectly influence soils by decreasing the risk of harm to soils as a result of high intensity wildfire, lowering the risk of loss of nutrients and loss of organic matter.

Proposed road re-construction (0.3 miles) and maintenance (8.5 miles) may increase short-term sediment movement from road surface runoff initially but should be minimal, especially at road locations higher on the slope that are at a relatively low gradient and provide for sufficient buffer zones. Road maintenance includes culvert replacement, blading, brushing, and typically improves drainage and/or decreases erosion resulting from water channeling down the road surface in the long run. For a detailed analysis and information on roads and related issues, please see the Hydrology report.

To summarize, by maintaining organic matter and ground cover on at least 85 percent of the site, nutrient cycling and availability should not be altered. The mitigations and Region 1 Soil Quality Standards are prescribed to achieve this desired outcome. Localized losses may occur under burn piles, at landings, or where severe fire occurs.

Cumulative Effects

Here we describe how old impacts, expected new impacts from fuel treatments and foreseeable future actions act together to influence long-term soil productivity. As mentioned, proposed treatments will employ low-impact logging techniques in an effort to minimize soil disturbance and maintain processes that promote natural soil bio-physical resiliency. We expect the effects of the fuels treatment not to exceed 40 years.

Effects from past actions are mainly limited to past timber harvest and road building. The area has recovered sufficiently from past wildfire in the early 1900’s. Approximately 27 acres, within units 11 and 22, have past harvest levels sufficient to require cut to length logging systems (which operate on a large slash mat to buffer effects). Furthermore, within units 11 and 22, machines will be restricted to skid trails only. Off trail traffic is eliminated to lessen overall impacts. Units 2 and 3 will also have cumulative impacts, primarily due to expansion of existing system road. Albeit, the system roads are a dedicated use and not part of the sustainable landbase. Both units will meet standards following the proposed action, although unit 3 has a higher relative percent dedicated to system road given the smaller unit area.

Cumulative Effects of Timber Harvesting

Undisturbed units (shown in Table 4 and 7) will experience the least, if any, cumulative effects from ground-based logging. Since litter layer is just now reaching maturity in units which initiated after wildfires in the early 1900s, additional activities that negatively influence soil organic matter will have cumulative influence.

Cumulative effects on moderately disturbed units 11 and 22 (9% and 7% existing detrimental disturbance, respectively) where ground-based logging and grapple-piling of slash are proposed, would not exceed regional soil quality guidelines for compaction with the require design features including logging system limitations. The prior disturbance warrants extra care to minimize additional disturbance. Restrictions are for robust slash mats and no off trail machine use. A cut to length system is desired since backhauling using feller buncher systems does not leave a continuous slash layer to operate. Cumulative detrimental disturbance after these restrictions would not exceed 15% detrimental disturbance. The impacts of these restricted harvest methods and past harvest are not wholly additive because approximately half of the existing skid trails and log landing sites would be re-used. These units are two of three units selected for effectiveness monitoring.

In addition, unit 3 has a high risk for adverse cumulative effects from new system road construction and lower levels of prior harvest at 2% detrimental disturbance. Using summer harvesting would lead to short term soil disturbance of approximately 14% compared to 12% disturbance with winter harvesting.

In regard to soil nutrient concerns, undisturbed units, typically those burned early in the 1900s, are just now reaching their potential for nutrient capital and efficient nutrient cycling. Treatments that minimize soil disturbance and leave slash on the ground for one season to leach available nutrients will not display cumulative effects. If, however, too much slash is used for biomass, or slash piling and burning becomes excessive, or the unit experiences a hot prescribed burn, then we can expect nutrient-based cumulative effects. Compliance with our required design features will ensure no cumulative effects.

Units which currently exhibit moderate (6-10%) to high (>10%) existing detrimental disturbance levels, as a result of past disturbances, are vulnerable to cumulative nutrient effects (Units 11 and 22, Table 4 and 7). Past harvest activities have removed considerable amounts of carbon and also decreased annual litter fall for a time. Most important, we must protect those elements and processes that maintain nutrient capital and cycling. Again, employing stated design features will ensure no cumulative nutrient-related effects.

Units which may be potentially potassium-deficient (possible for all units with belt sediment parent materials) will have slash left on site for at least one wet season in order to allow leaching of important nutrients back into the soil. Units where this is not possible and unmerchantable materials will be yarded (25, 26, and 28) are estimated to currently have at least 1-2 tons/acre of fine materials and will gain at least 1-2 tons/acre, due to harvest/yarding related breakage. Units 2 and 8a may also incur some yarding of unmerchantable material; however, the majority of these units will be broadcast burned following appropriate slash-leaching. None of these units have been previously harvested. Hence, these methods will be sufficient to retain potassium on site and potassium will not be a significant issue.

Page-Dumroese (2000) found that relatively small levels of disturbance (less than 15 percent of the area) resulted in relatively small losses in carbon, nitrogen, and cation exchange capacity (CEC), ranging between 1-13 percent of the available pools. She concludes that at these levels of loss, current soil quality guidelines appear to be adequate.

Region 1 soil quality standards require that we remain below 15% detrimental soil disturbance over the activity area in each treatment unit. Table 6 describes estimates of expected disturbance and also the expected risk of exceeding the threshold.

Refer to Table 5 for coefficients used to predict potential detrimental disturbance for proposed logging and slash treatment scenarios, including burning and piling. The level of additional, incremental disturbance also depends on the amount or lack of existing skid trails. Activity units that have had little prior disturbance will show a greater incremental increase in potential detrimental disturbance than those units that already contain a network of existing skid trails. Little to no increase in disturbance is expected in units with an existing network of skid trails because equipment would re-use existing skid trails. Rounding errors may occur.

Table 6: Summary of existing conditions and potential impacts for the Proposed Action following guidelines in Niehoff (2002) and the regional guidelines (1999b). Forest plan standards which integrate system roads into the analysis are addressed in Appendix C. Predicted additional detrimental disturbance percentages may not be equal to those projected in Table 5, as many of these units have existing levels of disturbance (related to existing skid trails, etc.) which will likely be re-used for this project. These predictions take into account the percentage of existing disturbance which can be re-used. (T=Tractor, CTL=cut to length, YUM=yard unmerchantable material, GP=grapple pile, B=burn, BB=broadcast burn, H=handpile, EPC=excavator pile corridors).

Unit #	Acres	Silviculture Prescription	Harvest System	Slash Abatement	Current Detrimental Disturbance (%)	Predicted Additional Detrimental Disturbance (%)	Estimated Total Detrimental Disturbance (%)-
1	15	Thinning	T or CTL	GP/B	2	11	13
2	60	Regeneration	Skyline	BB	2	3	5
3	18	Thinning w/ Group Selections	T or CTL	GP/B	2	12	14
4	24	Thinning w/ Group Selections	T or CTL	GP/B	2	12	14
5	7	Hazardous Fuels harvest; rock outcrops	Skyline	BB	0	2	2
6	22	Thinning	T or CTL	GP/B	2	11	14
7	14	Thinning w/ Group Selections	Combination (T/linepull)	BB	0	13	13
8a	22	Thinning w/ Group Selections	Skyline	BB/YUM	0	2	2
8b	12	Thinning	Skyline	EPC	0	5	5
8c	9	Regeneration	Skyline	BB	0	2	2
8d	4	Thinning	Skyline	EPC	0	5	5
9	7	Thinning	Skyline	None	2	1	3
10	36	Regeneration	Combination (T/linepull)	BB	2	12	14
11	17	Thinning	CTL	GP/B	9	5-6	14-15
12a	19	Thinning w/ Group Selections	Skyline	BB	0	2	2
12b	11	Thinning w/ Group Selections	Tractor Swing	GP/B	0	13	13
14	18	Regeneration	Skyline	BB	0	2	2

Table 6 cont. (T=Tractor, CTL=cut to length, YUM=yard unmerchantable material, GP=grapple pile, B=burn, BB=broadcast burn, H=handpile, EPC=excavator pile corridors).

Unit #	**Acres**	**Silviculture Prescription**	**Harvest System**	**Slash Abatement**	**Current Detrimental Disturbance (%)**	**Predicted Additional Detrimental Disturbance- (%)**	**Estimated Total Detrimental Disturbance (%)-**
15	23	Thinning w/ Group Selections	Helicopter	BB	0	2	2
16	4	Thinning	T or CTL	GP/B	0	13	13
17	36	Thinning w/ Group Selections	Skyline	BB	1	2	3
18	12	Thinning w/ Group Selections	T or CTL	GP/B	1	13	14
19	20	Thinning w/ Group Selections	T or CTL	GP/B	2	13	14
20	8	Regeneration	Skyline	BB	0	2	2
21	16	Thinning	T or CTL	GP/B	0	13	13
22	15	Thinning w/ Group Selections	CTL	GP/B	7	6-7	13-14
23	6	Overstory Removal	Skyline	None	2	1	3
25	19	Regeneration	Helicopter	YUM	0	0	0
26	9	Regeneration	Helicopter	YUM	0	0	0
27	23	Regeneration	Mechanical or Helicopter	BB	2	11** or 0-2	13** or 4
28	13	Regeneration	Helicopter	YUM	0	0	0
29	19	Thinning	Skyline	EPC	2	3	5
30	6	Regeneration	Skyline	BB	2	1	3
31	11	Thinning	T or CTL	GP/B	0	13	13
32	6	Hand Thin/Slash	Hand	HP/B	0	0	0
33	4	Hazardous Fuels harvest; rock outcrops	Skyline	BB	0	2*	2
34	6	Regeneration	T or CTL	GP/B	0	14	14

**with mechanical harvest

Cumulative Effects of Roads

Within units 2 and 3, approximately an acre of new system road building is planned which will bisect these units. Existing road prisms bisect proposed units 4 and 6. Table 7 outlines the mileage by unit.

Table 7. Existing and proposed system road mileage by proposed harvest unit.

Harvest Unit	Acres	Temporary Road (ft)	New System Road (mi)	Existing System Road (mi)
Unit 2	60	--	0.3	--
Unit 3	18	--	0.4	--
Unit 4	24	--	--	0.13
Unit 6	22	--	--	0.1
Unit 34	6	685	--	--

Using regional guidance, the planned construction of permanent, system roads are dedicated uses and thus will be removed from the sustainable land base. These areas are excluded from long term soil productivity assessments (USDA 1999b, Niehoff 2002). Sheetwash from road construction bare slopes will be short term as fill slopes re-vegetate.

All developed roads that are not currently designated as system roads have a lasting effect on soil productivity due to lasting compaction and displacement. Their existing template facilitates continued use that impedes natural soil restoration processes. As shrubs continue to re-establish, soil recovery will increase.

On roads that will be decommissioned, for the long term, infiltration rates may improve somewhat over time as freeze/thaw and plant roots improve soil porosity, though rates would likely remain lower than adjacent natural forest soil. The overall decommissioning of roads is a very strong benefit for soil productivity from a larger watershed perspective.

Cumulative Effects from Recreation

Disturbance from general motorized use and recreational access has been occurring and will continue throughout the project area indefinitely. No changes in the existing recreation profile are anticipated. Other recreational activities that occur off the developed roads, such as the gathering of miscellaneous forest products and hunting, are generally carried out on foot and have no additional effects on soils in the activity areas. In addition any unauthorized off-road, motorized use will be discouraged through implementation of certain design features (listed in the Recreation Report).

Cumulative Effects of Fire and Fire Suppression

In 1922 the last recorded large stand-replacing fire occurred in the project area. At least one other unrecorded, large fire likely occurred in the project area between 1926 and 1932 (see Vegetation Report). Since then the project area has not experienced a large wildfire, and fire suppression efforts have kept fires relatively small. The affected areas have recovered and no observable lasting effects to soils were found as a result of previous wildfires.

Active fire suppression has protected much of the Gold Crown area over the past decades but has added to increased fuel loading. The proposed harvest would aid future suppression activities by reducing current levels of infected dead and dying trees, thereby reducing the potential for larger scale fires. The benefits of fires with lower intensity and severity would include a reduced potential of excessive soil heating and sterilization as well as hydrophobic conditions that tend to increase sediment movement, flooding, and possible slope instability (deDios Benavides-Soloria and McDonald 2005, Neary *et al*. 2005).

On small wildfires, soil disturbance from fire suppression activities is usually caused by hand tools; most hand fire-line construction has only minor (insignificant) impacts to the soil resource. During fire suppression, closed roads may be reopened for access and incorporated as fire line. As part of the post-fire work, the areas of disturbance are rehabilitated and the roads returned to their previous condition in most cases.

Cumulative Effects of Grazing
No present, or foreseeable future domestic animal grazing occurs on National Forest System lands within the Project Area.

Cumulative Effects of Noxious Weeds
Noxious weed monitoring and treatment would occur as needed and would follow guidelines established in the Sandpoint Ranger District Noxious Weeds EIS (USDA 1998b). Effects to soil resources were analyzed in the document and its adaptive strategy. No additional effects to soils beyond what was analyzed for and disclosed in the EIS are expected to occur.

Features Designed to Protect Soil and Site Productivity

Below we have separated soil issues into three primary categories:

- Required Design Features: these are strategies and techniques designed to keep forest treatments in compliance with applicable USFS policies and applied to all treatment units;
- Additional Recommended Mitigation: these are recommendations that will further lessen detrimental soil disturbance.
- Soil Restoration Techniques: these are techniques applied to specific, damaged soils in all units, and strongly emphasized on those units that currently exceed 15% detrimental disturbance.

Required Design Features
As you plan to treat proposed units, there are many considerations and techniques to address before work commences. To demonstrate the effectiveness of design criteria, we have included details and references that substantiate our recommendations. Sources include primary literature and Forest Service monitoring results.

- Use existing skid and forwarder trails where practical. Carefully select trails for the least environmental degradation and optimal efficiency.

- Limit ground-based equipment to 40% slopes or less. Short pitches within these harvest units that are above 40% slope should be line-pulled and/or trees should be directionally-felled.

- Use skyline harvesting systems on steep slopes (greater than 40%). Maximize distance between harvest corridors.

    - Skyline systems are highly effective when employed correctly. Specifically this system drastically reduces compaction and soil displacement, compared to ground-based logging systems. (Niehoff 2002, USDA 2004).

- Conventional tractor/ skid trails should be no closer than 75 feet apart in the summer on dry soils. In the winter on snow or frozen ground, skid trails should be spaced no closer than 50 feet apart.
- Harvester/ forwarder trails should be spaced no closer than 50 feet apart, summer or winter.
- Maintain narrow trails, 10 feet in width or less.
- Grapple-piling should be accomplished from skid trails, forwarder routes or slashed-over harvester routes (slash mats).
- Leave as much slash as is feasible under fuel hazard guidelines. Organic matter helps ameliorate past and present soil impacts. Generally we recommend leaving 7 to 14 tons per acre on dry forest types and 16-33 tons per acre of coarse woody debris on moist forest types. Brown *et al*. (2003) recommends that if woody debris are greater than 6" in diameter, forest managers should leave amounts of woody debris on the high end of these ranges. If the size of the debris is small (less than 6"), strive for the lower end of the suggested range.
    - According to Graham *et al*. (1994), Brown et al. (2003) and Forest Plan Monitoring Reports (USDA 1998a, 1999a and 2000), this practice is highly effective.
- All equipment should stay on designated trails, with the exception of feller-bunchers and harvesters.
- Where feasible, timber harvesters should place slash in front of the harvest equipment and work on a slash mat.
    - According to project monitoring in the IPNF and primary literature, working on a slash mat has proven to be highly effective for reducing compaction and soil displacement (Han 2006; Niehoff 2002; USDA 2001, 2002 and 2003).
- For all ground-based logging, work only when soil is dry, frozen, or snow-packed. Some simplified guidelines for these conditions include:
    - Stop work when you detect trenching or mud. If you can form a fairly strong clod with the soil in the topmost 6 inches, then the site is too moist for work.
    - Winter harvest on Snow or Frozen Soil:

0 inches of frozen soil	Need 10 inches of machine-packed snow.
2 inches of frozen soil	Need 6 inches of machine-packed snow.
4 inches of frozen soil	No snow cover necessary.

    - Logging on snow and frozen soil is a highly effective method for reducing compaction, rutting, soil displacement and associated issues (Flatten 2003, Philipek 1985).

- If prescribed burning is proposed, wait an interval (at least 6 months) between the thinning and the underburn. This will conserve site nutrient capital; allow fine fuels to decompose and larger fuels to become firmly in contact with the soil, thus lessening their chance of complete combustion.
    - This technique has a high to moderate effectiveness rating based on research and Intermountain Forest Tree Nutrition Cooperative recommendations (Baker 1989, Barber and Van Lear 1984, Edmonds 1987, Garrison and Moore 1998, Laskowski *et al*. 1995, Moore *et al*. 2004, Palviainen *et al*. 2004).
- Broadcast burn when the topmost mineral horizon has moisture content of 25% or greater.
    - This practice is highly effective in retaining forest floor organic matter and associated nutrients (Niehoff 1985; Niehoff 2002; USDA 2001, 2002 and 2003).
- Monitor three tractor units (including units 11 and 22) that were harvested using either cut to length or other ground-based harvesting equipment within five years post harvest to evaluate compliance to R1 regional soil guidelines.
- For units 11 and 22, cut to length logging systems are required and must operate on a slash mat. All equipment must operate from skidtrails and slash mats only. Skidtrails spacing shall be spaced no closer than 50 feet.

<u>Additional Recommended Soil Conservation Measures</u>

- Select appropriate logging contractors for the task at hand. Be prepared to invest some time instructing contractors new to light-on-the-land and soil restoration techniques.
- If feasible, pre-pack snow on designated routes before work commences. This allows soil to freeze and the snow road to solidify.
- Minimize feller-buncher or harvester trips off of main trails to three passes.

<u>Soil Restoration Technique Descriptions</u>

This section provides recommendations for soil restoration. Although we do not expect any of the treatment areas to experience the amount or character of disturbance that might necessitate an aggressive restoration approach, we do expect log landings and similar disturbances may need active rehabilitation.

The primary concerns with any proposed road construction and/or timber harvest operation is compaction as well as the associated decrease in water infiltration rates and gas exchange. Compaction is evident throughout the forest, mostly on old skid trails.

Erosion and mass wasting are minor concerns, except on primary roads and regularly used OHV routes. Primary roads were not included in our study. OHV routes can be rehabilitated by seeding with an appropriate seed mix and placing slash on the trail.

Soil quality restoration takes time. No technique works immediately. Our primary objective is to direct and accelerate natural biologic processes and ecologic trends that will increase the forest soil ecological integrity. Fortunately, these techniques will also increase the forest's natural biological resiliency to future disturbances.

We derived the following recommendations through an approach that combines soil ecology and physics. Soil compaction can be remedied three ways:

1. Mechanical Ripping;
2. Freeze/ Thaw or Wet/ Dry Events;
3. Biological Activity.

1. *Mechanical Ripping*

Correctly ripping roads can be a challenge. Often, a dozer with ripper tines is used for the task. When ripper tines are used, it is important not to increase gully erosion by creating channels where water can flow down the ripped corridor. If we use a dozer for ripping, we recommend an implement with ripper teeth spaced at least every 12 inches, and approximately 20 inches in depth.

Ripping with an excavator takes longer, but does a much better job. When a compacted surface is mechanically ripped, it is very important that slash is also placed on the disturbance. Bradley (1990), found that slash will:

- Decrease the amount of surface sealing (caused when mineral soil is exposed to rain);
- Provide shade and associated soil moisture;
- Provide germination substrates & micro-sites that encourage native species while deterring weedy species;
- Increase biologic activity and all the associated benefits as described later.

In addition to slash, we and many others (Clearwater N.F., etc) found that lightly spreading forest litter over the disturbed area vastly increases biological resiliency and native plant re-establishment. Forest litter is an amazing source of dormant seeds and fungal inoculants. We estimate a cubic yard of forest litter can adequately cover more than 100 square yards of disturbance. This technique is especially useful on old slash pile burns.

Ripping should only be used on severely compacted soils, in relatively small areas. For example, landings & decking areas and primary haul roads could be ripped. Ripping skid trails is appropriate only if trails are benched with obvious cut & fill slopes or deeply trenched with obvious outside berms.

To avoid problems such as invasive weeds, soil structure damage, and hydrological issues, ripping should not be used to remediate soil compaction dispersed throughout a forest.

Ripping is not an appropriate technique for old, naturally vegetated skid trails. Many of these trails are healing naturally, and ripping might set them back. Unwanted impacts associated with ripping might include weed incursions, the mortality of existing native vegetation, and exposed mineral soil that is vulnerable to surface sealing and erosion. Skid trails described here are those that are quite difficult to see, typically on flat ground or slight slopes.

2. *Freeze/Thaw or Wet/Dry Events*

These are natural processes over which we have little control. In our ecosystem, these physical processes do assist in ameliorating compacted soils, especially fine-textured soils.

3. *Biologic Activity*

Promoting biologic activity is the best way to remediate damaged soils (Powers *et al*. 1998). Soil flora and fauna serve to break up compacted soils. Soil fungal processes are especially important, primarily mycorrhizae fungi and those associated with organic matter decomposition. Biologic activity influences many physical characteristics of the soil; including soil aggregation and associated water infiltration and gas exchange.

In an unpublished slash-use experiment at the Lubrecht Experimental Forest, we documented that the amount of water-stable aggregates significantly increased when slash was lopped & scattered on a severely disturbed soil. Water-stable aggregates and the associated increase in soil porosity began to form two years after treatments were initiated. Similarly, Guoyi Zou (2006) found that as soil organic carbon increased in the top 20cm over a period of 24 years, soil bulk density significantly decreased.

While performing a road inventory and soils analysis for the Clearwater District of the Nez Perce National Forest, we observed a relationship between log debris on skid trails and a distinctive lack of compaction. Though anecdotal, we have verified these same findings throughout the West, including the Clackamas District of the Hood River National Forest, the Three-Rivers District of the Kootenai National Forest, and the Sula State Forest near Darby, Montana.

Biologic activity is based on an appropriate supply, quality and arrangement of organic matter. In the forest ecosystem, organic matter can be found:

- On the forest floor – woody debris;
- In the organic horizon – litter layer;
- In the mineral soil (Soil Organic Carbon "SOC") – critical for aggregation and soil porosity.

Since soil organic matter and associated biologic activity is the best way to restore damaged soils, it is important to recognize and practice management activities that enhance the quantity and quality of forest soil organic matter. For sustainable forest use and forest soil restoration, we developed the following is a set of Forest Soil Organic Matter Management Guidelines:

Forest Soil Organic Matter Management Guidelines

Typically, forest litter contributions should balance with organic decomposition rates. This process depends on an adequate supply of needles and wood from the forest canopy or dying trees. Silvicultural prescriptions should consider this issue. If too many trees are removed from a forest, organic matter is lost in several ways:

- Reduced canopy cover reduces the source of annual organic matter contributions;
- Reduced canopy cover and associated forest floor heating increase organic matter decomposition rates.

To use biologic activity to reduce soil compaction, logging slash is the best tool:

- Place slash on old and new trails at a rate of 25 to 40 tons per acre (TPA).
- Leave slash throughout the forest at a rate of 5 to 15 tons per acre on dry forest types and 15 to 25 tons per acre on moist forest types, (Graham et al. 1994).
- We recommend debris should encompass a variety of sizes, for example:
    - 40 - 60% of the TPA larger than 12 inches in diameter;
    - 20 - 40% between 12 inches and 6 inches in diameter;
    - 25 - 40% between 6 inches and 1 inch in diameter;
    - 1 - 5% green needles.

- For those units that require soil restoration treatments, we strongly recommend using in-woods processors and log forwarders. This equipment reduces the risk of further soil degradation and increases the efficiency of using slash to increase soil biological activity.

Project Monitoring

In compliance with Forest Service policy, the Idaho Panhandle National Forest plans to monitor post-treatment soil conditions. Monitoring emphasizes the effectiveness of design criteria included in this report and compliance to Forest and Regional Soil Quality Standards. Units 11 and 22 were selected since these units use restoration oriented approach to accomplish logging with emphasis on slash for machine buffering and inputs of organic material for soil amelioration in addition to no off trail machine travel. Only three units total were selected to ensure monitoring is accomplished given limited forest resources. Base level monitoring would use similar methods detailing the existing condition in this report.

CONSISTENCY WITH FOREST POLICY AND LEGAL MANDATES

The Proposed Action would comply with Forest Plan standards and Regional Soil Quality Standards (USDA 1999b) related to detrimentally disturbed soils.

Management direction in the IPNF Forest Plan (p. II-8) is to manage the soil resource to maintain long-term productivity. The objective is that management activities on forest land will not significantly impair the long-term productivity of the soil or produce unacceptable levels of sedimentation resulting from soil erosion. The standards included in the Forest Plan (pp. II-32 and 33) are:

Forest Plan Soil Standard #1

Soil disturbing management practices will strive to maintain at least 80 percent of the activity area in a condition of acceptable productivity potential for trees and other managed vegetation. Unacceptable productivity potential exists when soil has been detrimentally compacted, displaced, puddled, or severely burned as determined in the project analysis.

The Proposed Action would comply with this standard; all proposed activity areas are below soil quality limits for disturbance and maintain the acceptable productivity potential for trees and other managed vegetation (see Appendix D).

Forest Plan Soil Standard #2

Projects should strive to maintain sufficient large woody debris to maintain site productivity. Large woody debris is essential for maintenance of sufficient micro-organism populations.
The Proposed Action would comply with this standard; large woody debris retention would follow the research guidelines of Graham *et al*. (1994) (7-14 TPA on dry sites and 10-24 TPA on moist sites) to ensure the maintenance of site productivity (see Appendix B).

Forest Plan Soil Standard #3

In the event of whole tree logging, provision for maintenance of sufficient nutrient capital should be made in the project analysis.
Following the regional soils guidelines (USDA 1999b) will alleviate nutrient capital concerns. Specifically, allow nutrients to leach from green slash and follow organic matter management recommendations. Since we are proposing a "first entry" into most of the treatment units, we do not expect any nutrient deficiencies as a result of tree removal. In addition, in proposed treatments where unmerchantable material will be yarded, nutrient-rich green slash that will contribute nutrients for a time will be left on site for at least 6 months.

Region 1 Soil Quality Standards

Following all soil quality recommendations will ensure compliance with Region 1 Soil Quality Standards and the Idaho Panhandle NF Forest Plan (1987). The proposed actions were developed to meet or exceed compliance with Region 1 Soil Quality Standards and the Idaho Panhandle NF Forest Plan.

In 1999, the Regional Soil Quality standards were revised and now the standards specify that 85 percent of an activity area (i.e. treatment unit) must have soil that is in satisfactory condition. In areas where more than 15 percent detrimental soil conditions exists from prior activities, the cumulative detrimental effects from project implementation and restoration should not exceed the conditions prior to the planned activity and should move toward a net improvement. These standards do not apply to intensively developed sites such as rock quarries, developed recreation sites, administrative sites, and system or other permanent roads.

Detrimental soil disturbance is defined as compaction with more than a 20 percent increase in soil bulk density (for volcanic ash-influenced soils), wheel rutting more than two inches deep in wet soils, displacement of more than one inch of topsoil from an area greater than 100 square feet, severely burned soil resulting from high-intensity burns of long duration, increased surface erosion generally greater than one to two tons per acre per year, and soil mass movement due to management activities.

All Forest Plan and Regional Soil Quality Standards would be met. Soil-disturbing management practices would maintain at least 85 percent of the activity area in a condition of acceptable productivity potential.

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Appendix A: Regulatory Framework

Laws and regulations provide direction for the management and protection of individual resources. Forest Service manuals and handbooks, forest plans, and BMPs identify the methods and guidelines that individual actions must follow to comply with the laws and regulations. The applicable regulatory framework that provides direction for the protection of soil productivity comes from the following principal sources:

- 1987 Idaho Panhandle National Forests Forest Plan;
- FSM 2500 (WO Amendment 2500-90-2 and R1 Supplement 2500-99-1;
- National Forest Management Act of 1976 (NFMA);
- Code of Federal Regulations for Forest Planning (36 CFR 219.6);
- Multiple-Use Sustained-Yield Act of 1960 (MUSY);
- FSH 2509.18 (WO Amendment 2509.18-91-1 and R1 Supplement 2509.18-2005-1);
- Best Management and Soil and Water Conservation Practices.

1987 Idaho Panhandle National Forest Plan

Management direction in the IPNF Forest Plan (p. II-2) is to manage the soil resource to maintain long-term productivity.

The objective in the IPNF Forest Plan (p. II-8) is that management activities on forest land will not significantly impair the long-term productivity of the soil or produce unacceptable levels of sedimentation resulting from soil erosion. This will be accomplished using technical guides developed in conjunction with the soil survey and Best Management Practices necessary to protect soil productivity and minimize sedimentation.

The forest-wide standards (USDA 1987, p. II-32 and 33) are based on older Regional soil quality standards. These include:

- Soil-disturbing management practices will strive to maintain at least 80 percent of the activity area in a condition of acceptable productivity potential for trees and other managed vegetation. Unacceptable productivity potential exists when soil has been detrimentally compacted, displaced, puddled, or severely burned as determined in the project analysis;
- Projects should strive to maintain sufficient large woody debris to maintain site productivity, and;
- In the event of whole tree yarding, provisions for maintenance of sufficient nutrient capital should be made in the project analysis.

FSM 2500

The Watershed and Air Management Manual as amended by WO 2500-90-2 states that management activities are to be implemented: (1) in order to optimize sustained yields of goods and services without impairing the productivity of the land; or, (2) in a manner that will improve soil productivity to take full advantage of its potential for increasing the productivity of forest and rangelands; or, (3) to rehabilitate soils that are in an unsatisfactory condition. In addition, soil quality monitoring will be implemented to determine changes in long-term soil productivity and to advise decision-makers when adjustments are needed in land management practices to protect or improve soil productivity.

The regional supplement to this manual (R1 Supplement 2500-99-1, USDA 1999) provides further guidance for soil quality monitoring and provides definitions for the parameters of the soil resource, detrimental disturbances, and monitoring techniques. This supplement stresses that one of the objectives of the Forest Service is to manage National Forest System lands under ecosystem management principles without permanent impairment of land productivity and to maintain or improve soil quality. Soil quality is maintained when erosion, compaction, displacement, rutting, burning, and loss of organic matter are maintained within defined soil quality standards.

FSH 2509.18

The Soil Management Handbook, as amended by WO 2509.18-91-1 and supplemented by R1 2509.18-2005-1, provides direction for monitoring and evaluation within the forest planning process and mirrors the manual direction described above for project implementation.

Code of Federal Regulations for Forest Planning

36 CFR Part 219 Section 6(b), 2006, requires that forest plan monitoring shall determine the effects of the various resource management activities on the productivity of the land.

Multiple-Use Sustained-Yield Act of 1960

Section 6(a) and (b) of MUSY directs the Forest Service to manage all of the various renewable surface resources of the national forests so that they are utilized in combination and to achieve and maintain in perpetuity a high-level annual or regular periodic output without impairment of the productivity of the land.

Best Management and Soil and Water Conservation Practices

Best Management Practices (BMPs) used by the Forest Service are outlined in the Soil and Water Conservation Practice (SWCP) (USDA 1987) and correlate to BMPs identified in the Idaho Forest Practices Rules and Regulations (IDAPA 20.02.01) and the Washington Forest Practices Rules and Regulations (Title 222 WAC). These BMPs provide standard specifications for the road construction and timber sale contact provisions to meet or exceed the rules and regulations pertaining to the Idaho Forest Practices Act, Title 38, Chapter 13 and the Washington Forest Practices Act RCW 76.09. While the ultimate goal is the protection of water quality in compliance with the Clean Water Act, implementation of the BMPs address erosion concerns of soils.

APPENDIX B: SUMMARY TABLES AND RESULTS

Table B.1: Existing disturbance assessment by unit.

Unit #	Existing Detrimental Disturbance (%)
1	2.2%
2	2.4%
3	2.4%
4	2.2%
5	0.0%
6	2.2%
7	0.0%
8a	0.0%
8b	0.0%
8c	0.0%
8d	0.0%
9	2.2%
10	2.2%
11	8.9%
12a	0.0%
12b	0.0%
14	0.0%
15	0.0%
16	0.0%
17	1.1%
18	1.1%
19	1.7%
20	0.0%
21	0.0%
22	6.7%
23	1.7%
25	0.0%
26	0.0%
27	2.2%
28	0.0%
29	2.2%
30	2.2%
31	0.0%
32	0.0%
33	0.0%
34	0.0%

Table B.2: Woody debris and organic horizon depth summaries by unit

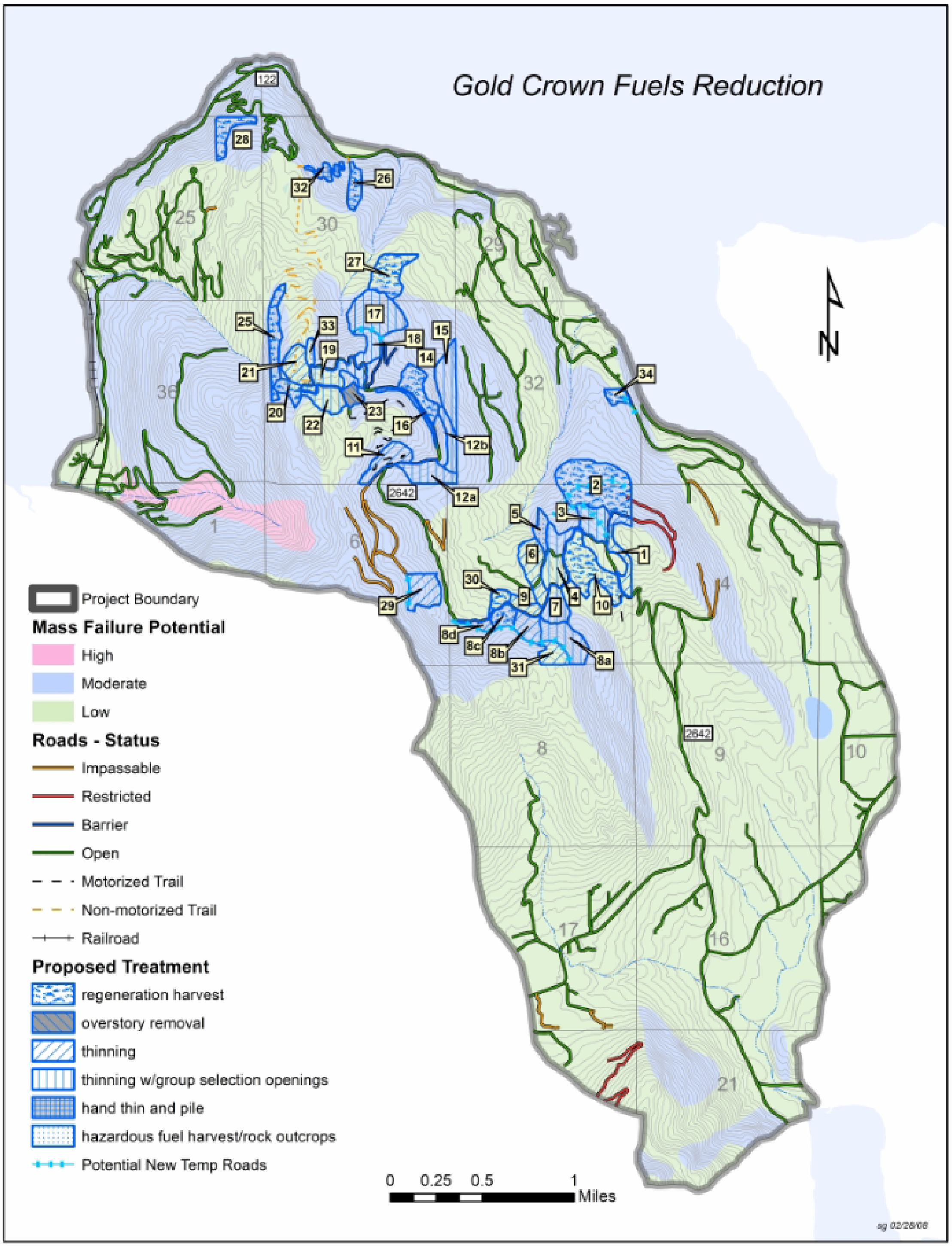
Unit #	Down Woody Debris (T/Ac.)	Organic Horizon, Average Depth (cm)
2	10.43	3.05
3	8.83	3.00
4	6.02	1.86
5	9.70	2.75
6	6.02	1.86
7	11.46	4.00
8a	11.46	4.00
8b	11.46	4.00
8c	11.46	4.00
8d	11.46	4.00
9	6.02	1.86
10	6.02	1.86
11	9.03	3.00
12a	4.83	2.00
12b	4.83	2.00
14	4.83	2.00
15	12.35	2.90
17	15.38	3.00
18	15.38	3.00
19	16.95	1.63
20	9.65	3.88
21	16.95	3.86
22	9.65	1.80
23	16.95	1.63
25	8.76	3.30
26	14.55	2.38
27	8.58	2.92
30	6.02	1.86
31	11.46	4.00
32	14.55	2.38
33	21.50	3.83
34	6.93	2.50

Table B.3: Forest floor cover by unit

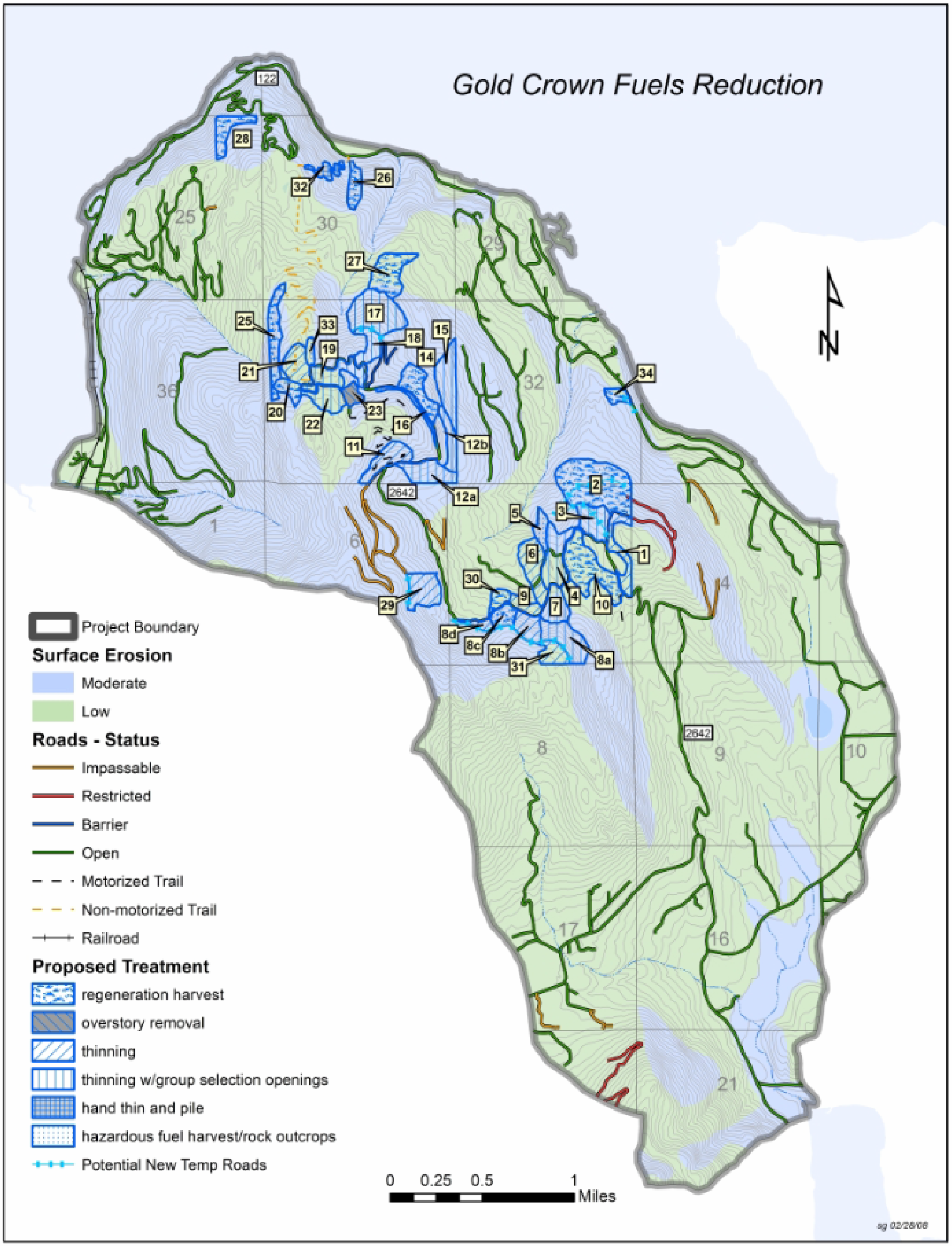
Unit #	Bare Soil	Rock	Vegetation	Litter	Wood	Total
2	1.8%	5.3%	38.2%	44.1%	10.6%	100.0%
3	2.9%	5.9%	30.0%	50.6%	10.6%	100.0%
4	2.2%	5.4%	30.4%	57.6%	4.3%	100.0%
5	2.9%	14.3%	5.7%	77.1%	0.0%	100.0%
6	2.2%	5.4%	30.4%	57.6%	4.3%	100.0%
7	1.1%	4.2%	6.3%	70.5%	17.9%	100.0%
8a	1.1%	4.2%	6.3%	70.5%	17.9%	100.0%
8b	1.1%	4.2%	6.3%	70.5%	17.9%	100.0%
8c	1.1%	4.2%	6.3%	70.5%	17.9%	100.0%
8d	1.1%	4.2%	6.3%	70.5%	17.9%	100.0%
9	2.2%	5.4%	30.4%	57.6%	4.3%	100.0%
10	2.2%	5.4%	30.4%	57.6%	4.3%	100.0%
11	4.3%	4.3%	8.5%	74.5%	8.5%	100.0%
12a	2.2%	13.0%	13.0%	63.0%	8.7%	100.0%
12b	2.2%	13.0%	13.0%	63.0%	8.7%	100.0%
14	2.2%	13.0%	13.0%	63.0%	8.7%	100.0%
15	0.0%	3.3%	30.0%	63.3%	3.3%	100.0%
17	1.1%	5.6%	18.9%	64.4%	10.0%	100.0%
18	1.1%	5.6%	18.9%	64.4%	10.0%	100.0%
19	3.3%	10.0%	53.3%	23.3%	10.0%	100.0%
20	0.0%	0.0%	12.0%	72.0%	16.0%	100.0%
21	0.0%	2.1%	20.0%	60.0%	17.9%	100.0%
22	6.7%	6.7%	37.8%	44.4%	4.4%	100.0%
23	3.3%	10.0%	53.3%	23.3%	10.0%	100.0%
25	0.0%	1.1%	34.4%	57.8%	6.7%	100.0%
26	3.3%	20.0%	36.7%	30.0%	10.0%	100.0%
27	1.1%	5.6%	30.0%	54.4%	8.9%	100.0%
30	2.2%	5.4%	30.4%	57.6%	4.3%	100.0%
31	1.1%	4.2%	6.3%	70.5%	17.9%	100.0%
32	3.3%	20.0%	36.7%	30.0%	10.0%	100.0%
33	0.0%	4.4%	28.9%	46.7%	20.0%	100.0%
34	0.0%	4.0%	16.0%	74.0%	6.0%	100.0%

APPENDIX C: SOILS MAPS

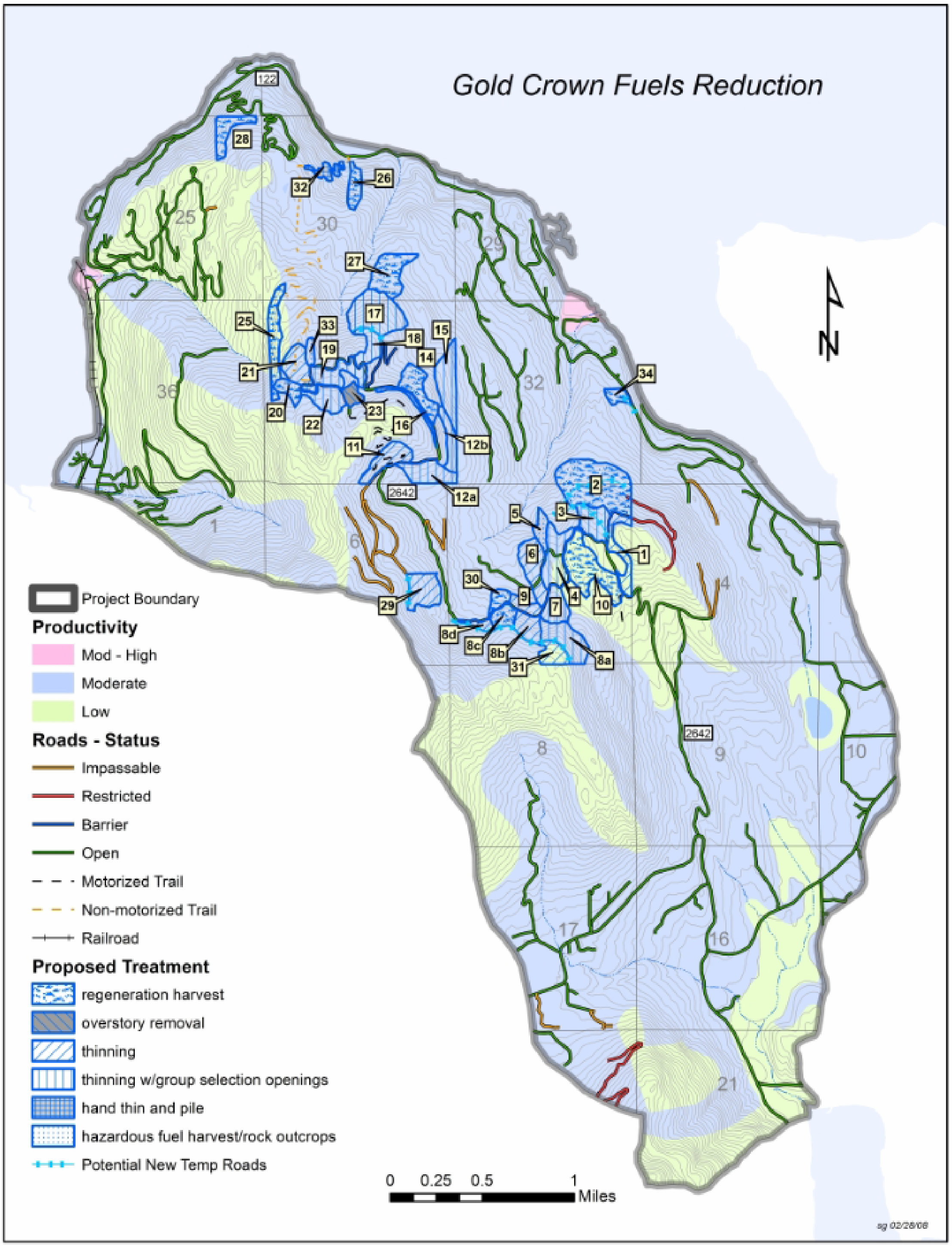
Map 1: Mass Failure Potential.



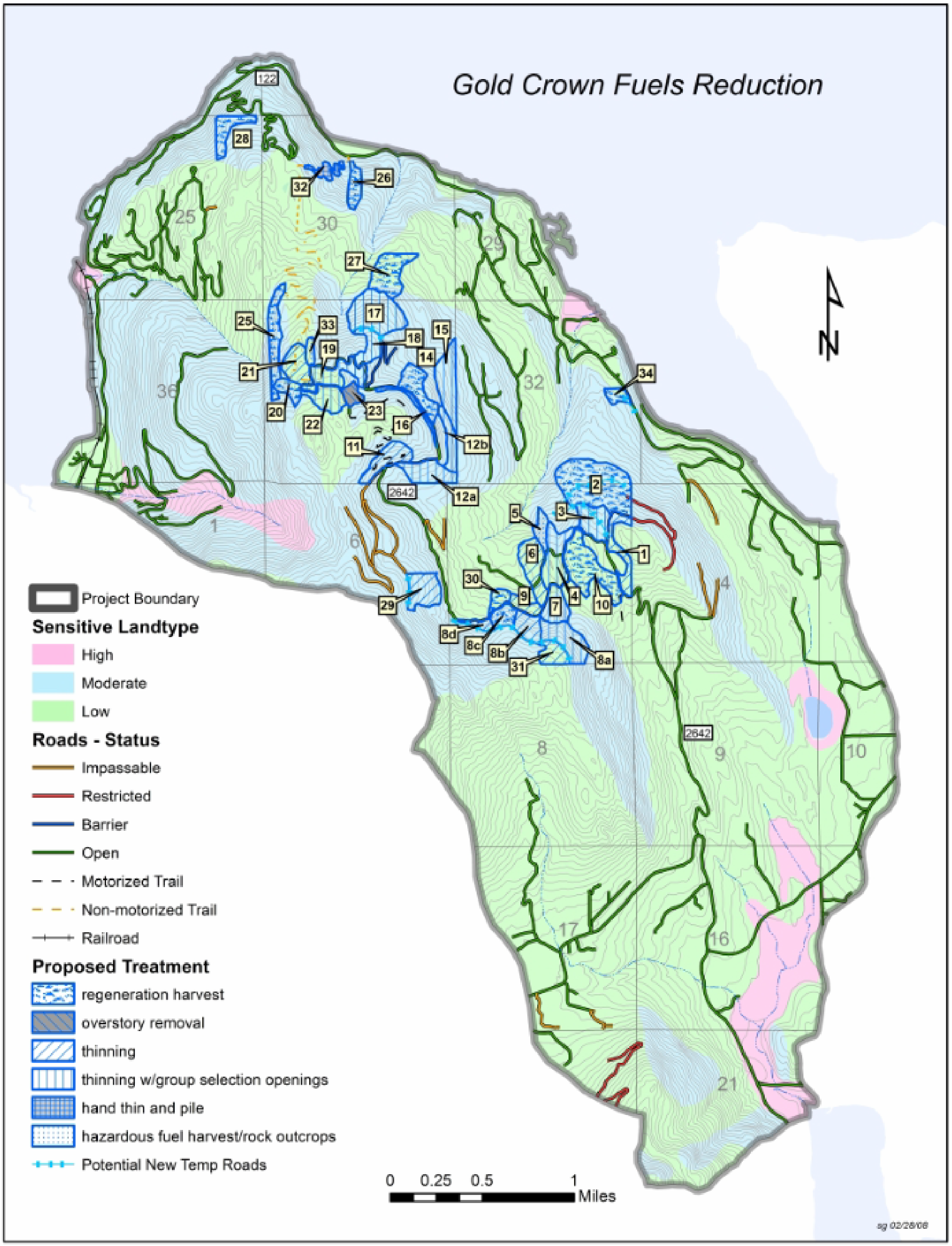
Map 2: Surface Erosion Hazard



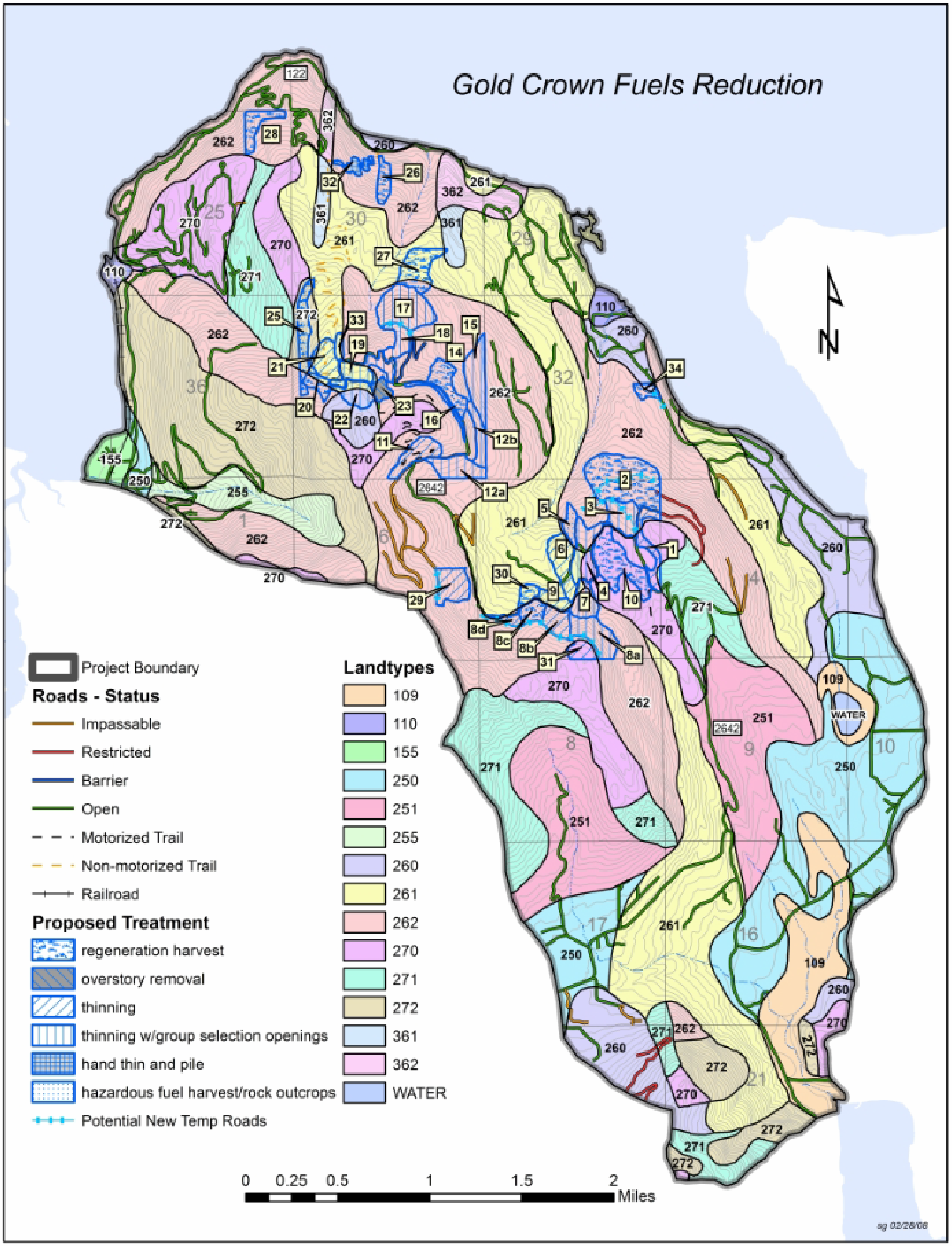
Map 3: Soil Productivity



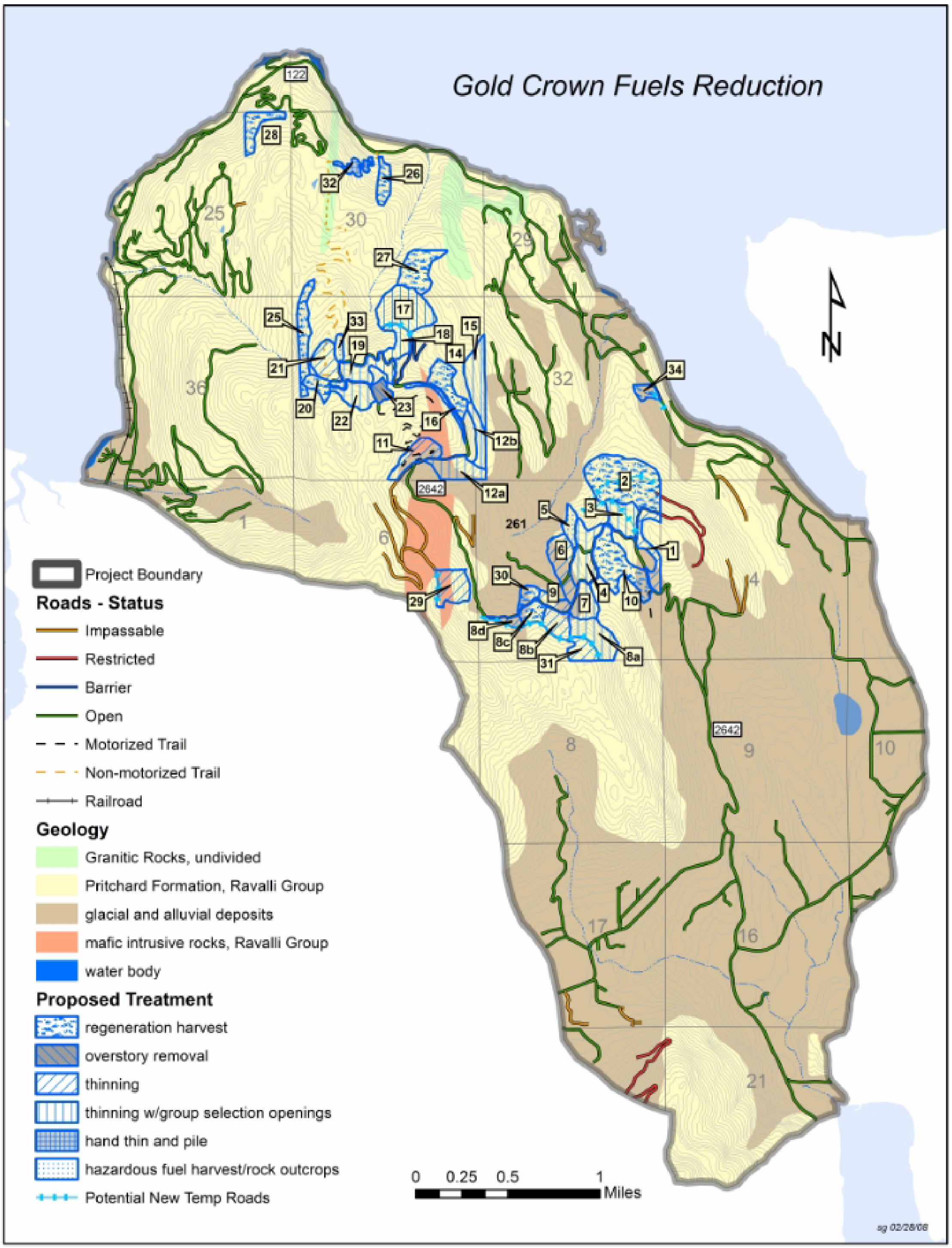
Map 4: Landtype Sensitivity



Map 5: Landtypes



Map 6: Geology



APPENDIX C: DETRIMENTAL DISTURBANCE FOR UNITS USING FOREST PLAN STANDARD OF AT LEAST 80% IN ACCEPTABLE PRODUCTIVITY

Table C.1 identifies estimated soil impacts based on the proposed action. Table 1 documents soil disturbance based on proposed harvest operations, field-verified impacts, and existing system roads that dissect units within each activity unit. For the proposed action, the results document that all units are below the required 20 percent impact as identified in the Forest Plan Standards.

The Forest Plan standards do not exclude system roads from analysis. See the hydrology analysis for watershed level analysis that includes system roads. All units except for unit 3 would be well within Forest Plan standards for detrimental disturbance. Unit 3 has relatively high amount of system road construction compared to the small amount of treatment area at 18 acres thereby leading to a high potential level of disturbance at 19 percent.

Table C.1: Estimated detrimental impacts on soils from past and proposed activities including system roads. (T=Tractor, CTL=cut to length, YUM=yard unmerchantable material, GP=grapple pile, B=burn, BB=broadcast burn, H=handpile, EPC=excavator pile corridors).

Unit #	Acres	Silviculture Prescription	Harvest System	Current Detrimental Disturbance- w/ roads (%)	New Road building acres (system/ temp)	Projected Additional Detrimental Disturbance- Winter (%)	Estimated Total Detrimental Disturbance (%)-Winter	Projected Additional Detrimental Disturbance- Summer/Fall (%)	Estimated Total Detrimental Disturbance (%)- Summer/Fall
1	15	Thinning	T or CTL	0	--	10	10	13	13
2	60	Regeneration	Skyline	2	0.9	2*	3^	5*	5^
3	18	Thinning w/ Group Selections	T or CTL	2	1.2	16	17^	18	19^
4	24	Thinning w/ Group Selections	T or CTL	2	--	10	11^	13	14^
5	7	HF harvest; rock outcrops	Skyline	0	--	2*	2	2*	2
6	22	Thinning	T or CTL	2	0.1	11	12^	14	15^
7	14	Thinning w/ Group Selections	Combination (T/linepull)	0		10*	10	13*	13
8a	22	Thinning w/ Group Selections	Skyline	0		2*	2	2*	2
8b	12	Thinning	Skyline	0		5	5	5	5

Unit #	Acres	Silviculture Prescription	Harvest System	Current Detrimental Disturbance- w/ roads (%)	New Road building acres (system/ temp)	Projected Additional Detrimental Disturbance- Winter (%)	Estimated Total Detrimental Disturbance (%)-Winter	Projected Additional Detrimental Disturbance- Summer/Fall (%)	Estimated Total Detrimental Disturbance (%)- Summer/Fall
8c	9	Regeneration	Skyline	0		2*	2	2*	2
8d	4	Thinning	Skyline	0		5	5	5	5
9	7	Thinning	Skyline	2		2	3^	2	3^
10	36	Regeneration	Combination (T/linepull)	2		10*	11^	12*	14^
11	17	Thinning	T or CTL	9		10	15^	10	15^
12a	19	Thinning w/ Group Selections	Skyline	0		2*	2	2*	2
12b	11	Thinning w/ Group Selections	Tractor Swing	0		10	10	13	13
14	18	Regeneration	Skyline	0		2*	2	2*	2
15	23	Thinning w/ Group Selections	Helicopter	0		2*	2	2*	2
16	4	Thinning	T or CTL	0		10	10	13	13
17	36	Thinning w/ Group Selections	Skyline	1		2*	3	2*	3
18	12	Thinning w/ Group Selections	T or CTL	1		10	11	13	14
19	20	Thinning w/ Group Selections	T or CTL	2		10	11	13	14
20	8	Regeneration	Skyline	0		2*	2	2*	2
21	16	Thinning	T or CTL	0		10	10	13	13
22	14	Thinning w/ Group Selections	T or CTL	7		10	13^	10	15^
23	6	Overstory Removal	Skyline	2		2	3	2	3
25	19	Regeneration	Helicopter	0		0	0	0	0
26	9	Regeneration	Helicopter	0		0	0	0	0

Unit #	Acres	Silviculture Prescription	Harvest System	Current Detrimental Disturbance- w/ roads (%)	New Road building acres (system/ temp)	Projected Additional Detrimental Disturbance- Winter (%)	Estimated Total Detrimental Disturbance (%)-Winter	Projected Additional Detrimental Disturbance- Summer/Fall (%)	Estimated Total Detrimental Disturbance (%)- Summer/Fall
27	23	Regeneration	Mechanical or Helicopter	2		10**	11	13**	14
28	13	Regeneration	Helicopter	0		0	0	0	0
29	19	Thinning	Skyline	0		5	5	5	5
30	6	Regeneration	Skyline	2		2*	3^	2*	3^
31	11	Thinning	T or CTL	0		10	10	13	13
32	6	Hand Thin/Slash	Hand	0		0	0	0	0
33	4	HF harvest; rock outcrops	Skyline	0		2*	2	2*	2
34	6	Regeneration	T or CTL	0		11	11	14	14

*projected disturbance over 60 years if burned once every 30 years (burned at year 0, year 30 and year 60)

**with mechanical harvest

^These numbers were calculated assuming approximately one-half of existing skid trails, existing landing sites, or other existing disturbance patterns would be re-used.