Tumbledown Hazardous Fuels Reduction Project

Specialist's Report on Soils

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March 2007

1. Introduction

Much of the Tumbledown Project Area (see Map Appendix) has been subject to logging activities within the last 2 to 8 decades. Aerial photos from 1935 show evidence of ground-based harvest in the early part of the twentieth century. Past activities, primarily salvage logging, has occurred along FS Road 278 in the past twenty years (see Past Harvest Map in Map Appendix). The Tumbledown Project Area was therefore assessed for previous activities to determine the current level of soil disturbance on proposed harvest units. Landtypes and associated hazards, data collected, and observations are provided in this document with additional details being available in the project file. This document also describes site specific design criteria (Soil Appendix A).

The analysis conducted in this Categorical Exclusion (CE) focuses on how the Proposed Action would affect soil productivity in the immediate area of the proposed activities and whether or not standards would be met. The scope of this analysis is to assess the existing condition and effects to soil productivity within the vicinity of the proposed management activities.

Soil productivity is defined as the output of a specified plant or group of plants under a defined set of management practices, or total plant mass that is produced annually per unit area. The most productive part of the soil occurs near the surface at the contact between the forest litter and the mineral soil. This is also the part of the soil that is easiest to disturb by management activities. The analysis was therefore limited to this most productive portion of the soil.

2. Methodology

2.1 Analysis Area

The analysis area for soil resources encompasses all land within individual treatment units and associated temporary roads, non-system roads, and landings. Existing classified National Forest system roads are considered designated lands and, as such, the loss of soil productivity due to their construction will not be considered.

Treatment will be conducted on approximately 671 acres (PF SOIL-21) dominated by dry- and moist site vegetation including Douglas-fir, grand fir, cedar, western hemlock, and ponderosa pine occurring at an elevation of 2200-3200 feet on generally southern and western slopes ranging from flat to greater than 50%. There are 25 units ranging in size from 5 acres to 93 acres (Table SOIL-3). Harvest activities will be accomplished using methods described in the following table.

Table SOIL-1: Proposed action logging system and site preparation summary.

Description	Proposed Action (ac)	Description	Proposed Action (ac)
Tractor	287	Underburn	294
Cut-to-Length	208	Grapple Piling	366
Skyline	165	Hand piling	11
Fuelbreak	11		
Total	**671**	**Total**	**671**

2.2 Analysis Methods

Soil resource existing conditions were determined using TSMRS records, aerial photography, GIS data, and on-the-ground-visits. Landtypes and hazard ratings were gathered from landtype descriptions and characteristics described in the Idaho Panhandle National Forests Land Systems Inventory (PF SOIL-2, 3, 10 and 11) and were field verified in the Project Area during several visits by the Forest Soil Scientist (PF SOIL-1, 13, 14, 15, 16, and 17) and trained personnel (PF SOIL-8 and 9).

The regulatory framework is provided by the National Forest Management Act of 1976 (NFMA), the Multiple Use-Sustained Yield Act of 1960, and the Forest Plan and Regional Soil Quality Standards (2554.03 – R1 Suppl. 2500-99-1 – USDA FS 1999). The Regional Soil Quality Standards were revised in November 1999. Manual direction recommends maintaining 85 percent of an activity area's soils at an acceptable productivity potential with respect to detrimental impacts, including the effects of compaction, displacement, rutting, severe burning, surface erosion, loss of surface organic matter, and soil mass movement. This recommendation is based on research indicating that a decline in productivity would have to be at least 15 percent to be detectable (Powers 1990). 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 in soil quality. These standards do not apply to intensively developed sites such as permanent roads, mines, developed recreation and administrative sites.

Existing conditions and impacts from past activities (Table SOIL-3) were quantified using a combination of on-the-ground soil transects (the "Onsite Assessment Method" outlined in Niehoff (2002)), depth of organic matter, and amount of coarse woody debris (PF-SOIL 1). The approximate confidence level (±5 percent) is 90 percent (Page-Dumroese et al. 2006; PF SOIL-18). Potential impacts to the soil resource by proposed harvest activities were evaluated using the Soil Disturbance Spreadsheet (PF SOIL-4).

The disturbance spreadsheet model estimates the impacts of proposed activities on harvest units for each harvest method based on empirically derived coefficients that were obtained and averaged from numerous monitored sites throughout this Forest. The model is limited to the harvest and slash disposal methods for which coefficients have been determined, and its coefficients assume that Best Management Practices (BMPs) will be implemented. The model does not account for changes in soil type, the recovery of soils over time, or existing conditions. The coefficients used and the protocol for applying the Soil Disturbance Spreadsheet are included in the "Soil NEPA Analysis Process and Source of Soil Disturbance Model Coefficients" (Niehoff 2002).

3. Existing Condition

The most relevant soil productivity factors influenced by past management practices are (1) detrimentally disturbed soils, (2) loss of nutrients, (3) soils and productivity, and (4) wildfire. The following discussion discloses the existing condition for these factors.

3.1.1. Detrimentally Disturbed Soil

Detrimental soil impacts are defined as the proportion of an activity area that may be subjected to compaction, displacement, erosion, rutting, or severe burning due to a particular management activity such as harvest or fuels treatment, exclusive of committed resources such as system roads. The soils in an activity area are considered detrimentally disturbed when the following soil conditions exist as a result of Forest practices:

a. *For volcanic ash-influenced surface soils, compaction results in a 15% or more increase in bulk density, or a 50% reduction in water infiltration rates. Soil compaction reduces the supply of air, water, and nutrients to plants. Roads, ground-based yarding, and dozer piling are the major contributors to compaction.*

b. *Detrimental displacement is the removal of 1 or more inches (in depth) of any surface soil horizon, usually the A horizon, from a continuous area greater than 100 square feet.*

c. *Surface erosion is indicated by rills, gullies, pedestals, and soil deposition and should be kept within tolerable limits by retaining enough ground cover, depending on site characteristics.*

d. *Rutting consists of wheel ruts at least 2 inches deep in wet soils.*

e. *Burns that create very high temperatures at the soils surface when surface soil moisture content is low result in almost complete loss of surface and upper soil horizon organics. Hydrophobic (water-repellent) conditions may also reduce water infiltration, promote overland flow, and increase erosion. Many of the nutrients stored in these organics can also be volatilized and removed from the site in fly-ash (Amaranthus 1989; DeBano 1991; Garrison and Moore 1998).*

To determine impacts and extent of past soil disturbing activities in the areas identified for treatment, existing conditions were monitored during on-the-ground field observations (Table SOIL-3; PF SOIL-1).

3.1.2. Loss of Nutrients

Harvesting results in the removal of nutrients that have been accumulated in the wood and foliage over time. Of concern is the possible loss of potassium in the soil and its effect on forest health, especially the increased susceptibility to insects and disease (Garrison-Johnston et al. 2003) and a possible link between potassium deficiency and the lack of tree resistance to root disease (Garrison-Johnston et al. 2003). Research (Garrison-Johnston 2003; Garrison-Johnston et al. 2004; Moore et. al 2004a; Shen et al. 2001) suggests a complex balance between underlying geology and the natural deficiency of potassium in northern Idaho. Derived primarily from underlying geologic formations, potassium is a product of slow weathering processes in comparison to soil nitrogen, which can be replenished more rapidly through nitrogen fixation or atmospheric deposition.

Some geological formations of the metasedimentary Precambrian Belt Supergroup have a natural deficiency of potassium; however, the predominantly granitic rocks of the Project Area are not expected to be as low in potassium as Belt rocks (Garrison-Johnston 2003) but exhibit moderate to low soil nutrient status because of their poor ability for nutrient retention. The majority of proposed activity areas are on glacial alluvial material and granitic rocks (PF SOIL-12).

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 retained 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). It is therefore vital to recycle as many nutrients as possible before removal, which can be done by overwintering small-scale debris to leach out potassium (Baker et al. 1989; Barber and Van Lear 1984; Edmonds 1987; Garrison and Moore, 1998; Laskowski et al. 1995 and Palviainen et al. 2003).

The Intermountain Forest Tree Nutrition Cooperative (IFTNC) continues to research potassium contents within tree species and different rock types in order to establish specific thresholds for retention and effects of potassium on tree growth and resistance to root diseases (Mika 2005; Shaw 2005). Until these 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 (see "Features Designed to Protect Soils" in this document).

3.1.3. Soils and Productivity

The most productive part of the soil occurs near the surface at the contact between the forest litter and the mineral soil. This layer is frequently only a few inches thick but it contains most of the soil nitrogen, potassium, additional nutrients, and mycorrhizae that must be present for a site to be productive.

Underneath this organic horizon is volcanic ash that occurs as the surface layer of the mineral soil. The volcanic material accumulated from several Cascade volcano eruptions with most of the ash originating from Mt. Mazama (Crater Lake) in Oregon about 7,600 years ago. The top part of the ash is usually enriched with organic matter that is incorporated into this part of the soil. The ash has a high water- and nutrient-holding capacity, both of which are important for soil productivity, while the lower part of the volcanic ash contains less organic matter and is not as fertile. Below the volcanic ash, the subsoils and substratum tend to be medium to coarse textured.

Retaining coarse woody debris (CWD) and organic matter is important in maintaining the soil's most productive layer. CWD is defined as woody material derived from tree limbs, boles, and roots greater than three inches in diameter and in various stages of decay. It performs many physical, chemical, and biological functions in forested ecosystems and is also a key habitat component for many wildlife species and for stream ecology (Graham et al. 1994). Coarse woody debris in natural systems fluctuates with forest growth, mortality, fire, and decay.

Because CWD is such a valuable part of a functioning ecosystem, a portion of the material must be maintained to ensure that organic matter is recycled for long-term productivity. Harvest and slash burning should include precautions to maintain large wood to insure that soil function is maintained since both standing boles and down wood may be reduced.

3.1.4. Wildfire

Wildfire is a natural component in forest watersheds and commonly influences forest soils and watershed processes. However, as a result of fire suppression during the last century, natural fire regimes do not exist anywhere in northern Idaho today (Smith and Fisher 1997).

Depending on the intensity of the fire and the severity of its effects, wildfire can alter watershed soils by consuming the erosion-limiting litter layer at the top of soils and the binding organics within the soil (Ice 2003). Condensation of volatized organics on soil surfaces often result in water-repellant (hydrophobic) soil conditions (DeBano 1981; Doerr et al. 2000; Dyrness 1976) that can contribute to overland flow and increased in-channel failures (Ice 2003).

The fire history of the eastern shores of the Lake Pend Oreille area was described in the Environmental Impact Statement for the Packsaddle timber sale in 1995 and documents three major past fires. A wildfire in 1919 burned the upper sections of Tumbledown and Canyon Creeks, followed by several fires in 1926 that burned throughout the Tumbledown Project Area. A large fire in 1934 burned nearly all of the Project Area leaving only scattered portions unburned.

3.2. Landtypes and Associated Hazards

Twenty-four land types have been identified in activity units in the Proposed Action (PF SOIL-10). Detailed descriptions of each landtype are located in the soils section of the project file (PF SOIL-2, 3 and 6). Hazard ratings have also been compiled and are broken into subcategories of mass failure, productivity, surface erosion, and landtype sensitivity (PF SOIL-6 and 11); each is rated as low, moderate, or high for a particular land type as displayed in the following table.

Table SOIL-2: Sensitive landtypes associated with fuel treatment activity units for the proposed Tumbledown project.

	Mass Failure Potential (acres)			Surface Erosion Potential (acres)			Landtype Sensitivity (acres)			Soil Productivity (acres)			
	L	**M**	**H**	**L**	**M**	**H**	**L**	**M**	**H**	**L**	**LM**	**M**	**MH**
Proposed Action	635	30	6	656	15	0	466	198	7	131	6	514	21

L – Low; M – Moderate; H – High; LM- Low to Moderately Low; MH – Moderately High

Mass Failure Potential is the relative probability of downslope movement of masses of soil material. Besides natural failure, landslides or slumping can be triggered by a number of mechanisms, including harvest activities, severe burning, and related road building.

Mass Failure - Mass failures detrimentally disturb soils because organic matter, the productive ash layer, and even subsurface layers of the soil can be carried downslope during a failure. Within proposed activity units, 635 acres are on low, 30 acres are on moderate, and 6 acres are on potential high mass failure landtypes (Table SOIL-2; PF SOIL-6 and 11). These include a small portion of Unit 30, the southwest corner of Unit 19 above Lake Pend Oreille, and the southern boundary of Units 20 and 21 adjacent to FR278H.

No active slides or slumps were found during the field assessment with the exception of an unstable cut slope on FR1050 just south of Brush Creek above Unit 3 (PF-SOIL 15). Two small shoots containing signs of movement and erosion have developed in association with the cut slope and the road. No active slumping is apparent on the immediate surrounding slopes though pistol butted trees indicate creep.

Removal of forest canopy and cover from either clearcutting or wildland fire increases landslide occurrence (Megahan et al. 1978; Gray and Megahan 1981). 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. Megahan et al. (1978) found that landslide occurrence increased only slightly when overstory canopy was reduced from 100 percent to 11 percent, but increased dramatically when canopy closure went below 11 percent. 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 removal than tree crown removal.

Surface Erosion Potential is a rating of the relative susceptability of exposed soils to sheet and rill erosion.

Surface Erosion - Surface erosion hazard in proposed activity areas range from low (656 acres) to moderate (15 acres). None of the activity areas have a high surface erosion rating (Table SOIL-2; PF SOIL-6 and 11).

Roads are currently the primary source of erosion and sediment production in the Project Area. The dominant processes in roaded portions are surface erosion from bare soil areas of roads, including the cutslope, fillslope, and travelway. Revegetation of cutslopes and fillslopes 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 cutslopes and fillslopes 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 within the Project Area. Periodic large pulses of erosion may occur during intense water yield and overland flow events in interaction with road drainage systems.

Landtype Sensitivity is a rating that incorporates mass failure, surface erosion, sediment delivery potentials, and average slope gradient to determine a rating of low, moderate, or high sensitivity for landtypes.

Landtype Sensitivity – In the proposed activity areas, 466 acres are rated as low, 198 acres as moderate, and 6 acres as high (Table SOIL-2; PF SOIL-6 and 11). The high rating acres are synonymous to those under high mass failure potential and include a small portion of Unit 30, the southwest corner of Unit 19 above Lake Pend Oreille, and the southern boundary of Units 20 and 21 adjacent to FR278H.

Soil Productivity - Soil productivity is generally low to moderately low on 137 acres, moderate on 514 acres, and moderately high on 21 acres of the activity areas (Table SOIL-2; PF SOIL-6 and 11). Reduced productivity is mainly due to dry south- or southwest aspects and shallow, rocky soils. Regeneration may also be influenced by competition, especially shrubs.

Soil Productivity Potential is a rating of the relative capacity or ability of a soil to produce and sustain biomass. Low productivity areas a generally associated with shallow, rocky steep slopes on southerly aspects.

Table SOIL-3: Existing conditions and potential impacts from proposed harvest and temporary road construction for Proposed Action.

						Predicted Impact from Temporary Road			Potential Detrimental Disturbance#	
Unit	**Activity Area (acres)**	**Proposed Treatment**	**Proposed Logging System**	**Proposed Slash Treatment**	**Existing Detrimental Disturbance %**	**Prop. Temp Rd. Const. (miles)**	**Est. Road Disturbance (acres)***	**In Unit %**	**Est. Acres**	**In Unit Total %**
1 (northernmost part of former Unit 1)	22	ISW/CT	CTL	GP	12				3	12
2	39	ISW/CT	T	GP	8				5	14
3	93	ISW/CT	S	UB	1				2	2
5	5	ISW/CT	T	GP	0				<1	14
6+	40	ISW/CT	S	UB	4				2	6
7	22	ISW/CT	T	UB	12				3	13
8	18	CT	T	UB	13				2	13
9	14	ISW	S	UB	3				<1	5
10 (formerly larger; now split into 22 & 23)	11	ISW/CT	T	GP	3				2	14
12	49	ISW/CT	T	GP	4	0.21	0.9	0.02	6	13
14	18	ISW/CT	T	UB	6				2	13
15	21	ISW	T	GP	1				3	14
16	33	ISW/CT	CTL	GP	6	0.06	0.3	0.01	4	12
17	14	ISW	CTL	GP	2	0.09	0.4	0.03	2	14
18	11	ISW	S	UB	0	0.09	0.4	0.04	1	5
19	25	Liberation	T	GP	3				4	14
20	56	ISW/CT	T	UB	1				7	13
21	17	CT/Selective	T	GP	2				2	14
22 (formerly just Unit 10 and small portion of Unit 18)	7	ISW	S	GP	3				<1	8
23 (formerly just Unit 10 and small portion of Unit 18)	6	ISW	T	GP	3				<1	14
25 (former Unit 1)	33	ISW/CT	CTL	GP	12				4	12
26 (former Unit 1)	28	ISW/CT	CTL	GP	12				3	12
30 (former Unit 4)	44	ISW/CT	CTL	GP	7	0.12	0.5	0.01	5	12
31 (former Unit 1)	9	ISW/CT	CTL	GP	12				1	12
32 (former Unit 6)	25	ISW/CT	CTL	GP	4	0.14	0.6	0.03	3	13
99 Fuelbreaks	11	Selective		Hand pile					0	0
	671					0.71	3.1		69	

ISW – Irregular Shelterwood
CT – Commercial Thin

S – Skyline
T – Tractor
CTL – Cut to length

GP – Grapple Pile
UB – Underburn

#Refer to PF SOIL-4 for coefficients used to predict potential detrimental disturbance for proposed logging and slash treatment scenarios including burning and piling. The level of disturbance increase 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 there because equipment would re-use existing skid trails and move on slash mats whenever possible.

*Assuming an avg. width of 35 ft. The majority of temp roads will be constructed on already existing old roadbeds and will be obliterated.

+There is a potential that Unit 6 would be logged with mechanized felling equipment and yarded with skyline as displayed above. Potential detrimental disturbance levels would adjust to 10% (PF SOIL-22); mechanized felling equipment would be limited to slopes <40%; the unit is expected to remain below required soil quality standards.

3.3. Field Data and Assessment

Between May and November of 2005, the proposed units were field checked and data was recorded to estimate the degree of soil disturbance (PF SOIL-1). Onsite assessment followed guidelines in Niehoff (2002) and included shovel tests and digging of holes on random transects to determine soil characteristics, compaction, organic matter depth, and coarse-woody debris content of proposed activity areas. Transects were also supplemented by visual observation and photos during the walk-throughs (PF SOIL-13, 14, 15, 16, and 17).

Unfortunately, several unit numbers, logging systems, delineations, and acreages were changed (usually downsized) after the majority of the units were visited during the field season in 2005. This results in slight differences in the original unit monitoring assessment and the currently proposed activity area delineations (for additional clarification see PF SOIL-5). The most prevalent changes occurred in regards to old Unit 1 (now split into Units 1, 25, 26, 30, and 31), portions of Units 10 and 18 (now Units 22 and 23), and Unit 6 which was split into 32 (proposed ground-based) and 6 (proposed skyline). The field data (PF SOIL-1) is summarized in Table SOIL-3.

3.4. Observations

The parent geology ranges from glacial or alluvial deposits, granodiorite of Whiskey Creek, Lakeview limestone to small portions of the metasedimentary Wallace formation of the Belt Supergroup (Miller et. al 1999; PF SOIL-12). Soils are generally well drained light to dark or reddish brown sandy or silty loams that formed in volcanic ash and the underlying parent material. Gravel and rock fragment content varies between 5-80% and increases in amount and size depending on shallowness or depth to bedrock.

Site visits have been made to all proposed ground-base units in order to assess existing conditions and to field check the data records (PF SOIL-1, 13, 14, 15, 16, and 17). More than a quarter of the proposed tractor ground (specifically Units 5, 10, 12, 15, 17, 19, 20, 21, 22, 23 and 32 – totaling 236 acres) has 4% or less existing detrimental disturbance to the soil and organic matter (Table SOIL-3). In general, existing impacts were found to be localized and limited to small areas within each unit. Where old stumps are present, the ground in proximity is usually undisturbed and no visible or physical evidence of skidding remains. In areas where roads or skid trails are visible, the soil may be compacted, may also only show slight disturbance, or has recovered.

A large amount of coarse-woody debris is present in most units. Root rot, insect, and wind and ice damage have accumulated increased amounts of fuels that are scattered on the ground as well as being dispersed and interlocked as ladder fuels aboveground. This combination of fuels and dense canopies are of serious concern if a fire should occur in this area. Should the organic matter be removed, the damage to soils from severe burning as well as the potential for erosion on steeper terrain could be of concern.

4. Environmental Consequences to Soils

4.1. Methodology Used to Analyze Environmental Consequences to Soils

Soil quality standards are applied to “activity areas” or individual harvest units (USDA FS 1999). The activity area is considered an appropriate geographic unit for assessing direct and indirect soil environmental effects because soil productivity is a site-specific attribute of the land and is not dependent on the productivity of an adjacent area. Similarly, if one acre of land receives soil impacts – i.e. reduced soil porosity, water holding capacity, aeration, long-term productivity etc. – and a second management activity is planned for that same site, then soil cumulative effects are possible. One exception would be the evaluation of slope stability, which requires a closer look at the adjacent terrain outside of activity areas to determine if cumulative effects from management activities and roads are adverse.

Spatial Scale - the appropriate scale, or geographic bounds, for the effects analysis relates to an area that would be affected by the proposed action or reasonable alternative – the analysis area for direct, indirect, and cumulative effects for this project is therefore confined to the “Activity area”. The task of selecting the geographical boundaries involves several factors, including the scope of the project considered and the features of the land. However, evaluation of cumulative effects to soil productivity does <u>not</u> require an integrated “watershed-type” assessment since that is not considered an appropriate geographic area. This is because assessment of soil quality within too large an area can mask or “dilute” site specific effects. Cumulative effects due to physical, chemical, and biological impacts often increase with the scope of past and proposed activities (Reid and Hilton1998).

Temporal Scale - the temporal scale is dependent on the specific issue being addressed with no one scale being appropriate for all issues. The analysis may need to evaluate the effects of proposed management over all seasons for several days, years, decades, or perhaps centuries. This is complicated by data constraints that require monitoring to detect change – though data are often insufficient to identify even trends or trajectories of change until the impact

is large enough or has been occurring for some time. Furthermore, there is often a lag between some action and its observed effect. This analysis strives toward an integrated approach to soil processes and function to project future trends in response to proposed management options to the best of abilities.

To determine whether proposed activities would detrimentally impact or have cumulative effects on soils, the IPNF Soil NEPA Analysis Process (Niehoff 2002) was used. The detrimentally disturbed acres were calculated using coefficients based on past IPNF soil monitoring data. The coefficients were developed as an average soil disturbance level and equated to harvest equipment, fuel treatment methods, and the time of year fuel treatment took place. This monitoring information is contained in Forest Plan Monitoring and Evaluation Reports and is summarized in the IPNF Soil NEPA Analysis Process (Niehoff 2002). Calculations incorporated the acres and types of proposed logging, burning, and roads associated for the evaluation of direct and indirect effects. Detrimental disturbance associated with the Tumbledown Project would be an irretrievable commitment of soil resource because soils are expected to recover over the long-term following detrimental disturbance from proposed vegetation management activities.

Generally, detrimental effects on soils are not permanent and depend primarily on soil texture, parent material, aspect, and level of disturbance, i.e. compaction. Recovery time is on the average 30 to 70 years as second growth timber becomes established around disturbed areas (Dykstra and Curran 2002; and Froehlich et al. 1983 and 1985). However, soil displacement that mixes or moves the volcanic ash surface layer and reduces soil moisture holding capacity and productivity is essentially irreversible.

Road calculations used 35-foot widths that take into account a 14-foot wide running surface and the cut and fill slope disturbance; however, on gentle ground, the road width is usually less (~12 to 15 ft.). Acres of detrimental disturbance were calculated by multiplying activity area size by the disturbance coefficient derived from monitoring reports (Niehoff 2002). Coefficients used for proposed logging systems are displayed in the following table.

Table SOIL-4. Potential detrimental disturbance coefficients used for various logging and prescribed fire scenarios.

Tractor Harvest	**Detrimental Disturbance Coefficients (%)**
With grapple piling or underburning	13
Cut-to-length logging with forwarder yarding	11
Aerial Harvest	
Skyline with underburning	0 - 2
Skyline with grapple piling	8

Based on past monitoring efforts (Niehoff 2002), tractor logging prior to 1990 has had the most detrimental soil impacts and ranged between 24 and 42 percent. Since 1990, tractor logging methods and recommended protection measures have decreased most detrimental impacts to an average of 13 percent (Niehoff 2002), which is two percent less than the maximum allowable criteria established by the Regional guidelines (USDA FS 1999).

Helicopter and skyline/cable logging systems tend to have between 0 to 2 percent detrimental effects (Niehoff 2002; McIver and Starr 2000, pp. 11-16). These logging systems have less impact than tractor systems because the equipment stays on the road and the logs are partially suspended, restricting impacts to times when logs are being dragged over the ground (Krag 1991; Seyedbagheri 1996, pages. 7-9).

Direct effects on soils from proposed activities were measured by analyzing the effects of compaction, erosion, burning, rutting, and displacement on the soil surface that is the most productive layer and also the easiest to disturb through activities. Potential impacts are based on the type of logging system and fuel treatments used and also include areas disturbed due to the construction of temporary roads.

Compaction, rutting, displacement, and severe burning can affect the soils physical, chemical, and biological properties, which indirectly can affect the growth and health of trees and other plants. Compaction and rutting reduces soil permeability and infiltration, which can cause soil erosion. Displacement reduces plant growth where topsoil and organic matter are removed. Severely burned soils can become hydrophobic (water repellent) and lead to increased erosion, runoff, and/or reduced productivity.

Roads and landings that are to remain on the landscape for future use can cause irretrievable effects on productivity as those lands become “dedicated” lands. Those roads that are temporarily needed for project work and are planned for decommissioning have initial detrimental effects, but rehabilitation efforts (ripping, incorporation of woody material etc.) would initiate a long-term recovery sequence. Vegetative recovery time is approximately 30 to 70

years as the second growth timber becomes established around the disturbed areas and develops enough crown foliage to intercept and evapotranspirate moisture (Dykstra and Curran 2002; and Froehlich et al. 1985).

Indirect effects include the loss of site productivity due to the removal of large woody debris and nutrients that are usually bound in branches and needles. Large woody debris is essential for maintenance of sufficient microorganism populations and long-term site productivity. Research has indicated that potassium (among other nutrients) is an important element for site productivity and may be deficient in certain metasedimentary Belt Supergroup formations and granitics. Design features are incorporated into the activities to meet the management of large woody debris and organic matter as detailed in the research guidelines contained in Graham et al. (1994). These recommendations emphasize tons per acre and are defined as any woody residue larger than three inches in diameter.

Cumulative effects include the combination of direct and indirect effects from past, present, and reasonably foreseeable activities. Direct, indirect, and cumulative effects on soils are measured within each activity area although adjacent land outside of the activity area is considered as well, primarily in regards to slope stability. Existing roads and landings designated as classified on the National Forest transportation system are considered dedicated lands and hence are not part of the cumulative effects. The loss of soil productivity on these sites occurred when the roads and landings were constructed and are an irretrievable effect.

4.2. Direct and Indirect Effects

4.2.1 Direct and Indirect Effects Common to No Implementation and the Proposed Action

Direct and Indirect Effects of Wildfire

If a wildfire occurred in the Tumbledown Project Area, consequent resource damage from mechanized suppression activities and burn severity could range from negligible to severe, depending on location, size, severity of burn, and subsequent administrative activities. Primary risks for erosion and mass failure would be from breaklands, steep slopes, and associated roads, especially at stream crossings in the event of debris flows. Loss of soil productivity could be extended depending on burn severity, location, and post climate characteristics. Following a severe fire, rehabilitation efforts to mitigate the fire's effects on erosion and sediment delivery would likely occur and reduce potential negative effects.

The continued accumulation of dead and down fuel loads contributes to an increased potential for locally severe fire effects on soil. Deteriorating effects of wildfires on soils usually include loss of organics and nutrients and a reduction of water infiltration (Wells et al. 1979, p. 26). High intensity burns that create high soil surface temperatures, particularly when soil moisture content is low, can result in a complete loss of soil microbial populations, woody debris, and the protective duff and litter layer over mineral soil (Hungerford 1991; Neary et al. 2005). Since erosion increases following a fire are often directly proportional to fire intensity (Megahan 1990, p. 146), the removal of ash-capped surface soils could reduce soil productivity.

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 (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 site specific locations or watersheds are difficult to predict and to quantify.

4.2.2. Direct and Indirect Effects of No Implementation

With no implementation, no new management-induced detrimental direct or indirect impacts would occur in the Tumbledown Hazardous Fuels Reduction Project Area. No effects to soils would take place as no temporary road construction and fuel treatments would be added. Conversely, none of the existing unclassified roads (totaling ~1 mile) and classified roads (totaling ~0.2 miles) would be decommissioned.

There would be no compaction or displacement beyond what currently exists. Soil potassium, nitrogen, and other nutrients would continue to cycle, build up at current rates, and not be subject to removal due to fuels reduction. Soil nutrient cycling would continue at low rates from rock weathering, atmospheric deposition (mostly nitrogen), and nitrogen fixation. Soil nutrients would be bound in organic matter complexes and slowly released through decay.

On a landscape scale, the restoring of ponderosa pine, western larch, and white pine would not occur. Timber stands would continue to reflect past management practices that selectively harvested seral species, leaving the more

pathogenically prone and soil nutrient demanding Douglas- and grand firs. Stand conversion to more site-appropriate tree species would be delayed or may never occur relative to the Proposed Action.

Stands currently at high mortality risk would not be treated, which may increase the risk of stand loss due to disease, wildfire, severe burning, erosion concerns, and loss of soil nutrients. Moreover, the introduction of weeds and unwanted flora following a fire could lead to higher competition between less desirable plants and native vegetation.

4.2.3. Direct and Indirect Effects of the Proposed Action

Direct and Indirect Effects of Harvest Activities - The proposed vegetation and fuel treatment activities are expected to remove site nutrients with the harvest of tree boles on 671 acres using a combination of ground-based logging (~496 acres or 74 percent), skyline system (~165 acres or 24 percent), and several hand-thinned fuel breaks (~11 acres total or 2 percent) (Table SOIL-1; PF SOIL-21). These vegetation management activities and associated temporary roads (Table SOIL-5) have the potential to cause detrimental soil disturbances, such as compaction and displacement, by removing an estimated 69 acres of the total activity area from a productive growing state (Table SOIL-3; PF SOIL-4 and 7). All landings associated with skyline and ground-based harvest would be located along existing or temporary roads. Table SOIL-3 displays harvest units and their assigned logging prescription for the Proposed Action. All of the 25 proposed harvest units would meet regional soil quality and Forest Plan standards.

There is a potential that Unit 6 would be logged with mechanized felling equipment and skyline yarded as originally planned. Potential detrimental disturbance levels would increase to 10% (PF SOIL-22) with mechanized felling equipment being limited to slopes <40%. The unit is expected to remain below required soil quality standards.

The level of soil disturbance increase depends primarily 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 contain a network of already existing skid trails (Table SOIL-3). Effects on soil productivity from these activities are site specific attributes of the land on which they occur.

Soil compaction effects can last for decades but are not irreversible. Recovery processes vary greatly with soil texture, clay content, and their interaction with climatic processes such as cycles of freezing-thawing and wetting-drying (Dykstra and Curran 2002; Landsberg et al. 2003). Persistence of compacted soil and, presumably, long-term consequences of compaction for tree growth depend on the severity of the initial compaction, the ability of species to cope with compacted soils, and rates of processes that decompact the soil (Cromack and others 1979; Froehlich and McNabb 1983; Froehlich et al. 1985). Soil displacement that mixes or removes the volcanic ash surface layer, however, reduces soil moisture holding capacity and associated productivity, which is essentially irreversible.

Harvesting the tree bole only would remove about 14 percent of the tree's potassium potentially causing indirect effects to some plants. Following the management recommendations from the Intermountain Forest Tree Nutrition Cooperative (IFTNC) would minimize any additional loss of potassium and nutrients from treated areas by overwintering slash.

The logging slash from tree limbs, tops, and un-merchantable pieces would remain within all harvest units and be allowed to overwinter before being underburned or grapple piled. This would allow the foliage and branches to leach and recycle nutrients back into the soils' organic layer, primarily potassium. Determination of fire risk where slash is left untreated for prolonged periods of time will be made by the district fire management officer. Where fire risk is considered high, especially near the roadside, near structure, or in fuel breaks, flexibility will be given to treat slash prior to it being left for 6 months.

Additional improvements would include favoring western larch, ponderosa pine, and western white pine that require less potassium than species with increased abilities to sequester nutrients, like Douglas-fir or grand fir (Garrison and Moore 1998; Moore et al. 2004b).

Following recommendations from Graham et al. (1994), approximately 5 to 15 tons/acre should be present to maintain forest productivity on dry sites whereas 17 to 33 tons per acre should remain in moister cedar/hemlock habitats. However, the amount of coarse woody debris will likely be kept at the lower end of the recommendations in several locations near structures or roadsides in order to address the hazardous fuels reduction requirements. Retention of more desirable existing trees in many areas, especially ponderosa pine and larch, will also contribute litter and provide potential CWD in the future.

Timber harvesting would open up tree canopies and logging slash from tree limbs, tops, and un-merchantable pieces would add to existing short-term fuel loadings. Canopy removal would allow wind and sunlight to penetrate, heat, and dry the debris, which could increase potential fire intensity and severity until the slash is treated or naturally abated. However, the long-term risk for a stand-replacing wildfire would be reduced by creating more open stand

structures that would have lower accumulations of large diameter fuels and that would be less likely to support crown fires.

Indirect effects of soil wood loss include altered processes of forest regeneration and growth, favoring species requiring lower soil moisture, lower nutrient levels, and greater potential for soil erosion. Potential loss or reduction of organic matter can lead to a decline in several key soil and foliar nutrients (Powers 2005). Additional effects could also include loss of habitat for species requiring soil wood as dens or substrate for invertebrates, bacteria and fungi, which affect food availability for small rodents and their predators.

Direct and Indirect Effects of Fuelbreak Treatments – Treatments are planned on 11 acres of hand-thinned fuelbreaks to reduce fuel loads near private boundaries and structures. No mechanized equipment would enter the parcels; therefore, no disturbance from compaction, displacement, or rutting of soils would occur. Localized impacts to soils from pile burning may happen but are expected to be of short-term (1 to 3 years), especially if soil moisture levels are high. Flexibility will be given to timing of burn treatments due to the close proximity of the parcels to adjacent private land.

Direct and Indirect Effects of Prescribed Burning and Slash Disposal - Post-harvest site preparation is proposed on 671 acres and consist of 388 acres (58 percent) of grapple piling, 272 acres (41 percent) of underburning, and 11 acres (1 percent) of hand piling (Table SOIL-1; PF SOIL-21). No measurable negative effects on soils are anticipated from post-harvest underburning if soil moisture content is equal or above 25 percent when the burning occurs (Niehoff 1985 and 2002). When soils have adequate moisture conditions to retain their biological, chemical, and physical integrity, effects from the loss of forest floor can be minimized (Barnett 1989; Frandsen and Ryan 1985; Hungerford et al. 1991; McNabb and Cromack 1990).

In the south- and southwest facing units, the prescribed burns would have limited detrimental effects when executed in the spring. Burning under controlled conditions of high soil moisture reduces potential nutrient losses and the chance of creating hydrophobic soils that can lead to increased erosion, sedimentation, and debris flows (Ice 2003; Neary et al. 2005; Robichaud 2000; Swanson 1981).

When burn piles are large, nutrient losses from heat and volatilization could be considerable. In some cases, burning of the slash piles may create localized patches of hydrophobic soils for as much as one to three years (Huffman et al. 2001) but the areas are generally not large or extensive enough to alter slope hydrologic responses or long-term soil productivity.

However, on an unpredictable site-specific basis, some drier sites may underburn at a severity level that removes all of the protective duff and litter layers, even under managed fire conditions. The duff and litter layer is important in protecting the soil horizons, both as reducing erosion potential and in maintaining soil moisture. Litter prevents the breakdown of soil aggregates and lessens the velocity of any overland flow, thereby decreasing the erosion potential (Beschta et al. 2004). Direct effects of prescribed underburning and pile burning could potentially remove woody debris that would otherwise provide nutrients to the soil as the decay process occurs (Page-Dumroese et al. 2006).

Design features also require piling machinery to utilize existing trails, operate on a slash mat whenever enough material is available, and stay on slopes less than 40 percent to prevent soil disturbance in excess of guidelines. Only areas that could be reasonably accessed would be treated and none of the trails would be excavated to facilitate access. The residual logging debris that would be lopped and scattered or that could not be grapple piled and burned would increase potential fire intensity and severity for a few years until snow could compress the debris and the fine organics would decompose.

Severe burning and ground disturbance could create bare soils and encourage noxious weed infestation. Design features are therefore incorporated to lessen disturbance impacts in activity areas in order to prevent extraordinary circumstances to the soil resource (Soil Appendix A).

Direct and Indirect Effects of Temporary and Non-System Road Construction and Decommissioning - Less than 1 mile of temporary road construction is proposed in six different units to move personnel, logs, and/or equipment to complete harvest and fuels treatments (see Table SOIL-5; PF SOIL-7). All roads would primarily be located on old roadbeds that currently exist at various degrees of recovery. Nevertheless, reconstruction would cause soil compaction, displacement, and effects to site productivity on approximately 3 acres (0.4% of total activity area) assuming an average road width of 35 feet (generally less on gentle terrain). Upon treatment completion, all temporary roads would be decommissioned, which includes culvert removal, decompaction and re-

Table SOIL-5: Proposed temporary roads.

Unit	Approximate Miles
12	0.21
16	0.06
17	0.09
18	0.09
30	0.12
32	0.14
Total	**0.71**

contouring of the road prism, seeding, and incorporating woody debris and organic matter. All landings would be located on system roads. Additional discussion of road effects can be found in the Specialist's Report on Hydrology.

Roads constructed in the past provide access to federal and private land in the Tumbledown Project Area. System roads were removed from productivity when they were constructed and have little additional effect on the area if they are properly maintained (i.e. functioning culverts, drainage structures, surface etc.). Minimal short-term impacts (days) to soils are anticipated from proposed road maintenance activities, which consist of blading, drainage improvement, and surfacing.

Conversely, unmaintained or improperly maintained roads are identified to be one of the main sources of sediment contribution to streams through erosion, sediment routing, and slumping. All currently impassible unclassified (non-system) roads (approximately 1 mile) reconditioned to provide access to treatment units will be decommissioned upon completion of management activities, thus helping the recovery of soil productivity, improving infiltration, and reducing hydrologic effects from road surface runoff (Switalski et al. 2004). Approximately 0.3 miles of currently open unclassified roads in the project area will be classified and added to the system, while approximately 0.2 miles of currently impassible classified roads will be decommissioned and removed from the system (PF SOIL-7).

4.3. Cumulative Effects of Past, Ongoing, and Reasonably Foreseeable Activities

4.3.1. Cumulative Effects of Not Implementing the Proposed Action

With no implementation, no new management-induced detrimental cumulative impacts would occur in the Tumbledown Hazardous Fuels Reduction Project Area. No effects to soils would take place as no temporary road construction and fuel treatments would be added. Conversely, none of the existing unclassified or classified roads would be decommissioned.

When combined with the effects of past and ongoing fire suppression, not implementing the proposed action would further increase the risk of severe stand replacing fires. Should such a fire occur, the continued accumulation of dead and down fuel loads could contribute to an increased potential for locally severe fire effects on soils, including physical alteration of soil structure and development of hydrophobic layers. With no implementation, no new management-induced cumulative impacts would occur in the Tumbledown Project Area.

4.3.2. Cumulative Effects of the Proposed Action

Cumulative Effects of Harvest Activities - Much of the Tumbledown Project Area has been subject to past logging activities that started with permanent land clearing and salvage logging around the turn and well into the beginning of the last century (see Past Harvest Map in Map Appendix; Summary table for past, present, and reasonably foreseeable activities – Project file Section O). Road construction made the area more accessible in the 1960s and the re-route of FS278 in the mid 1980s provided improved roads for numerous timber sales that started in the mid 1980s until early 2003. The most recent past impacts to soils overlap with several proposed units in the northern part of the Project Area and include primarily the Barton Hump (1995), Barton Way (1996) and Upper Cedar (2000) timber sales (see Past Harvest Map in Map Appendix). Some small sale activity, primarily salvage, has occurred along FS Road 278 in the past two decades. The legacy impacts to soils were observed and recorded during field visists and are reflected in the existing conditions (Table SOIL-3). Past impacts to soils are less apparent in activity areas located in the mid- and southern portion of the Project Area since most of the disturbances there occurred 3 to 8 decades ago.

Several private land parcels are also present within the Tumbledown Project Area and logging activities have taken place there since the first homesteaders arrived in the vicinity. However, activities on non-Forest Service land that detrimentally disturb soils and impair soil productivity are site specific and have no additional effects on the analysis area.

No other ongoing or reasonably foreseeable harvest activities are planned beyond what is proposed with the Tumbledown Hazardous Fuels Reduction Project.

Cumulative Effects of Roads – All developed roads built in the past for thoroughfare, access, or roads that are proposed for Tumbledown harvest activities have a lasting effect on soil productivity due to compaction and displacement. The main access road into the Project Area (FS278) was built in the 1960s and has since been expanded to provide access to numerous private parcels in the area. However, existing classified National Forest system roads are considered designated lands and, as such, the loss of soil productivity due to their construction will not be considered in the cumulative effects analysis.

Several smaller connecting unclassified roads have been closed and are overgrown and impassible. Proposed road reconditioning is planned on approximately 1 mile of unclassified roads (FS Road 278UG, 278UGAG, 278UKAQ,

and 278UKAR – see Transportation Summary Map in Map Appendix) out of which ~0.5 miles are located within activity areas 16, 23, and 25. Reconditioning would increase compaction and displacement and could add to short-term sediment movement from road surface runoff during the reconditioning phase. Upon completion of management activities, approximately 1 mile of reconditioned unclassified roads will be decommissioned, thus helping the recovery of soil productivity, improving infiltration, and reducing hydrologic effects from road surface runoff (Switalski et al. 2004). Additionally, approximately 0.3 miles of currently open unclassified roads in the project area will be classified and added to the system, while approximately 0.2 miles of currently impassible classified roads will be decommissioned and removed from the system (PF SOIL-7).

Road maintenance includes blading and brushing and typically improves drainage and decreases erosion from water channeling down the road surface. This management activity is ongoing and will extend into the reasonably foreseeable future. No additional roads are planned to be constructed beyond what is proposed with the Tumbledown Hazardous Fuels Reduction Project. For additional information on roads, please see Specialist's Report on Hydrology.

Cumulative Effects of Fire and Fire Suppression – Fires have been frequent within the Tumbledown Project Area from as early as the mid 1800s until 1934; however, since that last stand-replacing fire, wildfire suppression has extinguished human or natural fire ignition and has led to increased fuel loads. While wildfire suppression would continue in order to protect private property, water quality, and other resource values, the proposed treatments would increase the ability to safely use prescribed fire, periodically reducing fuel loads, and to suppress unwanted wildfires. There would therefore be a lower risk of wide-ranging severe fire effects to the soil resources post-harvest.

Cumulative Effects of Noxious Weeds - Noxious weed monitoring and treatment would occur as needed and would follow guidelines established in the Sandpoint 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.

4.4. Extraordinary Circumstances

Based on the rationale discussed above for the soils resource, the proposed action has the potential to cause detrimental soil disturbances, such as compaction and displacement, by removing an estimated 69 acres (10 percent) of the total activity area from a productive growing state (Table SOIL-3; PF SOIL-4 and 7). All of the 25 proposed harvest units would meet regional soil quality and Forest Plan standards. Therefore, there would be no extraordinary circumstances regarding this project for the soils resource.

5. Consistency with the Forest Plan and Other Regulatory Direction

IPNF Forest Plan Standards

Proposed management practices and existing conditions, including system roads, are below the limit of 20 percent impact for all activity units and meet Forest Plan standards (PF SOIL-19 and 20).

The Regional guidance to follow the coarse woody debris recommendations of Graham et al. (1994) would adhere to the Forest Plan Standard to maintain sufficient microorganism populations to maintain site productivity.

No whole tree yarding would occur.

Management area direction to implement Best Management Practices would be included in the proposed action.

Regional Soil Quality Standards

Proposed management practices in all activity areas would not exceed the recommended 15 percent.

Organic matter layer thickness would be retained as appropriate for local conditions.

Large woody debris would be maintained at recommended volumes (Graham et al. 1994) in each proposed activity area.

/s/ Regina G. Rone

IPNF Soil Scientist

Soils - Appendix A

Features Designed to Protect Soils

The following practices are designed to minimize the detrimental impacts of soil compaction, displacement, severe burning, and nutrient and organic matter depletion on long-term soil productivity. The use of these practices would insure that the soil quality standards listed in the Forest Plan and Regional Soil Quality Standards would be met and that extraordinary circumstances to the soil resource would be prevented.

Tractor Yarding - Existing skid trails and slash mats are used in previously logged units whenever available to reduce additional impacts from harvest and site preparation activities. All new skid trails are designated and laid out to take advantage of the topography and minimize disruption of natural drainage patterns. Where terrain is conducive, trails are spaced at maximum distance. Excavated skid trails are be fully re-contoured after logging is completed. All skid trails are seeded with the latest seed mix recommended at time of implementation. Equipment avoids operating in moist or wet depression areas. This specifically affects units 1, 2, 16, 17, 19, 25, 26, and 32 were seasonal seepage occurs.

- ***Estimated Effectiveness*:** High - These guidelines exceed the requirement of the Idaho Forest Practices Act and meet the Forest and Regional Soil Quality Standard by limiting disturbance to less than 15% of the activity area (Niehoff 2002; Adams 1997).

Skyline Yarding - The leading end of logs should be suspended during yarding. Yarding across any designated RHCA requires full suspension.

- ***Estimated Effectiveness:*** High; the intent is to reduce the potential detrimental soil impacts of displacement and compaction. Past Forest Plan monitoring (USDA Forest Service 2004) indicates low amounts of soil compaction and displacement with skyline yarding systems (Niehoff 2002). These systems tend to have less detrimental effects (McIver and Starr 2000, pp. 11-16; Poff 1996) than ground-based systems because equipment stays on the road and logs are partially or fully suspended over the ground. Soil impacts from skyline logging are caused when one end of a log is dragged over unprotected ground (Krag 1991; Seyedbagheri 1996 pp. 7-9).

Road Construction and Reconditioning - An engineer or hydrologist will review locations of all roads longer than 300 feet prior to construction. Temporary road construction proposed in Units 12, 17, 18, 30, and 32 and road reconditioning of existing non-system roads in Units 16, 23, and 25 utilizes the existing old roadbed where present will obliterate them after harvest activities are concluded. This includes culvert removal, decompaction and/or re-contouring of the road prism, seeding, and incorporation of woody debris and organic matter. In areas were current improvements are advantageous (i.e. FR1050), the road will be further stabilized to reduce adverse effects from slumping. All landings will be located on roads.

- ***Estimated Effectiveness:*** High - road location, particularly relative to streams, is a key factor in reducing road-related surface erosion at the scale of individual road segments. This feature is implemented through contract provisions, administration of contract provisions, use of appropriate Best Management Practices, and compliance monitoring by the sale administrator or engineering representative (Lynch and Corbett 1990; USDA Forest Service 1999b).

Protection of Landslide Prone Areas – Portions of several units are on potential high mass failure landtypes. These include a small portion of Unit 30, the southwest corner of Unit 19 above Lake Pend Oreille, and the southern boundary of Units 20 and 21 adjacent to FR278H. Limited cutting, modification of the unit boundary, or exclusion, especially when the area is adjacent to a cut slope, is recommended.

- ***Estimated Effectiveness:*** High - this practice would retain an appropriate amount of canopy cover and live roots to continue soil water uptake and stabilize soils (Gray and Megahan 1981; Megahan et al. 1978).

Nutrient protection on Machine or Hand-Piled Areas - The following soil nutrient management recommendations from the Intermountain Forest and Tree Nutrient Cooperative (IFTNC) and Rocky Mountain Research Station (RMRS) is applied as appropriate to each activity area where organic material is removed:

A. Practice conventional removal (lop and scatter) rather than whole tree removal. The "lop and scatter" technique should be practiced during intermediate as well as final harvest operations.

B. Let slash remain on site over winter so mobile nutrients such as potassium can leach from fine materials back to the soil.

C. Light broadcast burn or underburn for release of potassium and other nutrients.

D. Avoid mechanical site preparation.

E. Plant species appropriate to the site.

Slash should be left for one wet season over a minimum of 4 to 6 months (not including summer months from July through September) to recycle nutrients back into the soil. As this is a hazardous fuels reduction project, determination of fire risk where slash is left untreated for prolonged periods of time will be made by the district fire management officer. Where fire risk is considered high, such as along main roads, private land boundaries, and structures, flexibility will be given to treat slash prior to it being left for 6 months.

- ***Estimated Effectiveness:*** High to moderate - this practice is 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. 2004b; Palviainen et al. 2004).

Retention of Coarse Woody Debris - Management of coarse woody debris and organic matter will follow the USFS Region 1 guidelines from Graham et al. (1994). In units where existing coarse material is not sufficient (i.e. Units 5, 7, and 16), project activities ensure that enough coarse woody debris is left to sustain long term soil productivity, while still meeting fuel reduction objectives (Recommendations for these habitat types are 5-15 tons/acre for dry and 17-33 tons/acre for moist sites).

- ***Estimated Effectiveness*:** High - based on research (Brown et al. 2003; Graham et al. 1994) and Forest Plan Monitoring Reports (USDA 1998, 1999a, and 2000), effectiveness is high when guidelines are used; implementation has been moderately successful.

Protection during Grapple Piling or Mechanical Harvest Activities – Mechanical harvest or grapple piling equipment utilizes existing trails, operates on a slash mat whenever enough material is available, avoids saturated soil conditions, and stays on slopes less than ~40 percent to prevent soil disturbance in excess of guidelines. Only areas that are reasonably accessed by ground-based equipment are treated and none of the trails are excavated to facilitate access

Estimated Effectiveness: High - past Forest Plan monitoring (Han-Sup 2006; USDA Forest Service 2001b, 2002 and 2003) indicates reduced soil disturbance if equipment is operated on a slash mat.

Protection During Prescribed Burning Activities - Prescribed underburning and pile burning should take place only when the upper surface inch of mineral soil has a soil moisture content at or above 25 percent by weight or 100 percent duff moisture. This is particularly important in Units 1, 3, 6, 9, 10, 12, 14, 15, 16, 19, 20, 21, 25, 26, 30, 31, and 32 were soil productivity on the primarily west- and south-facing slopes is reduced and could be impacted through severe burning of the often shallow soils.

- ***Estimated Effectiveness:*** High - this practice is effective in retaining decomposing forest floor litter and organic matter to retain nutrients and soil productivity potential (Niehoff 1985, Niehoff 2002, USDA Forest Service 2001b, 2002, and 2003). When soils have adequate moisture conditions to retain their biological, chemical, and physical integrity, effects from the loss of forest floor can be minimized (Barnett 1989; Frandsen and Ryan 1985; Hungerford et al. 1991; McNabb and Cromack 1990).

Protection of Soils from Weed Infestation - Weed mitigation measures and prevention practices occurs in accordance with the requirements of the Sandpoint Noxious Weed Control EIS (USDA 1998b) for all landings and road disturbances.

- ***Estimated Effectiveness:*** Moderate to High – Mitigation measures are accepted weed prevention practices developed by public land management agencies and university cooperative extension offices and promoted by weed management organizations across the nation (Drlik et al. 1998; Sheley et al. 2002; USDA 2001a).

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