IX. SOILS

Introduction

This section discusses the components of the soil resource that could be affected by the proposed activities. They are:

- Soil productivity
- Soil erosion
- Mass failure or soil stability

Soil Productivity

Soil productivity is the ability of the soil to supply the water and nutrients needed to sustain plant growth. Characteristics that influence soil productivity include physical soil characteristics, organic matter and soil organisms.

Physical Soil Characteristics

The physical characteristics of concern are soil depth, the amount of pore space in the soil, and the density of the soil. Changes in soil characteristics occur when ground-based equipment makes repeated passes over the soil (Lull 1959). These activities compress or compact soils and if soils are wet enough cause rutting and puddling. All of these changes to the physical soil characteristics reduce the amount of pore spaces. This in turn reduces the movement of water into and through the soil and impedes root growth through soils, reducing a plant's ability to take up water and nutrients. Compaction and other physical soil disturbances alter the amount of carbon dioxide and oxygen in the soil, affecting both plants and animals that live in or on the soil.

Organic Matter

Organic matter in its various forms contributes to soil productivity. Humus is decomposed organic matter. Duff and litter consist of fresh or partially decomposed leaves, needles, and twigs that are still recognizable on the surface of soils. Large woody debris consists of woody stems greater than three inches in diameter (Harvey, et al. 1994, p.10). Decomposed large woody debris supplies moisture to plants after the soils dry out. All organic matter provides water and nutrients for soil organisms and plants. Garrison and Moore (1998) found 85 to 90 percent of the total nutrients in most coniferous trees are contained in the branches, twigs, and foliage. Prescott and Laiho (2002, p. 390) found the contribution of nutrients from large woody debris is relatively minor.

Soil Organisms

Soil organisms, including fungi and bacteria, drive nutrient cycling by decomposing organic matter, which releases nutrients for plant growth. Soil organisms depend on organic matter for

the nutrients they need to carry out their life processes. Decomposed large woody debris provides important habitat for the survival of mycorrhizae fungi. These fungi form a symbiotic relationship with tree roots, increasing water and nutrient uptake by the trees and the fungi (Perry, et al. 1990, p. 268).

Soil Erosion

Soil erosion is the movement of soil particles by water or wind. Water is the main cause of soil erosion on steep forested slopes. Erosion is infrequent on undisturbed forest soils for two reasons: first, abundant organic matter provides a protective blanket on the soil surface that reduces the impacts of raindrops and allows water to move into the soil; second, the surface soil below the organic layer is by its nature porous, allowing water to move rapidly into and through the soil profile (Goldman, et al. 1986 p.1.7).

Soil erosion can occur when the surface soil is compacted or when the loose surface soil and its protective layer of organic material are changed by management activities. Compaction, rutting, and puddling reduce the movement of water into the soil and tend to channel and concentrate water. As a result, water runs off (overland flow) and carries soil particles with it. Natural occurrences such as fire remove organic matter from the soil surface. When organic matter is removed, soil pores can be plugged by impact from raindrops resulting in overland flow and soil erosion.

Mass Failure

Mass failures can be caused by either natural or man-caused disturbances. Mass failures can result when a sequence of natural events, such as high precipitation or snowmelt, are followed by a trigger such as an earthquake. Some areas are prone to mass failures because of the nature of the geology or soil. Human disturbances such as roads can cause mass failures if road surface drainage is concentrated enough to saturate soils.

Mass failures triggered by human causes are detrimental soil disturbances. These disturbances cause long-term changes in soil productivity that last centuries.

Information Sources

Forest Service Manual Section 2550 and the Region 1 Supplement 2500-99-1 provide direction for maintaining soil quality. Beginning in 1982, bulk density samples have been taken from the Flathead National Forest in areas that were managed for timber production. Two statistical analyses of those bulk density measurements establish their validity in determining the effects of management on the ground. These reports are in the project file, section O. A study of soil moisture trends on the Flathead National Forest demonstrates the existence of a time when soils are dry enough (less than field moisture capacity) to reduce soil detrimental disturbances, a practice recommended in literature cited in this document. Literature has been cited that documents the effectiveness of design features proposed to reduce detrimental soil disturbance from the Red Whale Project. In addition, monitoring reports for activities on soils similar to those proposed are used to analyze the effects of the proposed activities. The information

gathered in the field was used to conduct the effects analysis. The results of field investigations are in Table 3-72; the field notes from those inspections are in the project record (see project file, section O).

Analysis Area Description

The analysis area forms the boundary for the direct, indirect and the cumulative effects soils analysis. It consists of the proposed activity areas for the Red Whale Project. This analysis area was selected because that is where the effects of implementing the proposed activities would occur. The effects on soils would not extend beyond the commercial thin units, sapling thinning units, or the prescribed burn units proposed for treatment.

Affected Environment/Existing Condition

In order to determine the existing condition of soils within the proposed activity areas, we conducted field investigations that determined how or if the existing soil condition was affected by past management activities and if soil conditions were present that required special design features. Specifically, we looked for areas that were wet or that had evidence of past harvest that caused compaction, displacement, rutting, puddling or soil erosion.

Either boot tip transects or walk-through observations were done to determine the extent of past harvest activities and their effect on the existing soil condition. Where roads, landings or skid trails were present and still showed evidence of detrimental soil disturbance, we used transects to determine their extent. In some cases we measured the length and width of obvious trails. Units that lacked evidence of any past soil disturbance were walked through, checked in a few places and noted as such on the field sheets.

Field sheets from the visits to proposed activity areas and a summary sheet are in the project file (section O). Table 3-72 summarizes the results of the field investigation. Proposed units that show two separate dates had past activities that occurred in separate places within the proposed units. The activities do not spatially overlap.

Table 3-72. Current Percent Detrimental Soil Disturbance for Proposed Units that had Previous Timber Harvest within the Project Area.

Unit Number	Acres in Proposed Units	Previous Commercial Harvest Activity	Date of Previous Activity	Current Percent Detrimental Disturbance	Comments on Existing Condition and Past Activities
A	5	None	NA	0%	Undisturbed by Mechanical Equipment
B	40	None	NA	0%	Undisturbed by Mechanical Equipment
C	21	None	NA	0%	Undisturbed by Mechanical Equipment
D	108	None	NA	0%	Undisturbed by Mechanical Equipment
E	38	None	NA	0%	Undisturbed by Mechanical Equipment
F	61	None	NA	0%	Undisturbed by Mechanical Equipment
G	196	Past Regeneration Harvest	1960	0%	Reusable skid trails and one old road with 6 to 10 inch diameter trees
H	78	Past Regeneration and Intermediate Harvest	1968, 1999	1%	Indistinct skid trails and an old road
I	87	Past Regeneration and Intermediate Harvest	1979	0%	Indistinct skid trails
J	164	Past Regeneration Harvest	1970s	1%	Reusable skid trails
K	59	Past Regeneration Harvest	1962, 1975	1%	Reusable skid trails
L	169	Past Regeneration Harvest	1950s, 1960s	2%	Reusable skid trails
M	123	None	NA	0%	
N	44	Past Harvest	1950s	0%	Indistinct skid trails
O	45	Past Regeneration Harvest	1980	1%	Reusable skid trails
P	82	None	NA	0%	Undisturbed by Mechanical Equipment
Q	53	None	NA	0%	Undisturbed by Mechanical Equipment
R	40	None	NA	0%	Undisturbed by Mechanical Equipment
S1	12	None	NA	0%	Undisturbed by Mechanical Equipment
S2	7	None	NA	0%	Undisturbed by Mechanical Equipment
S3	40	None	NA	0%	Undisturbed by Mechanical Equipment

Unit Number	Acres in Proposed Units	Previous Commercial Harvest Activity	Date of Previous Activity	Current Percent Detrimental Disturbance	Comments on Existing Condition and Past Activities
S4	46	None	NA	4%	Undisturbed by Mechanical Equipment
T1	10	None	NA	0%	Undisturbed by Mechanical Equipment
T2	17	None	NA	0%	Undisturbed by Mechanical Equipment
T3	10	None	NA	0%	Undisturbed by Mechanical Equipment
T4	283	None	NA	0%	Undisturbed by Mechanical Equipment
U	9	Past Sanitation Salvage Harvest	1984	0%	Indistinct skid trails
V	11	Past Harvest	No Records	8%	Indistinct skid trails
W	14	None	NA	2%	Undisturbed by Mechanical Equipment
X	34	Past Sanitation Salvage Harvest	1989	1%	Indistinct skid trails
Y1	53	None	NA	0%	Undisturbed by Mechanical Equipment
Y2	26	None	NA	2%	Undisturbed by Mechanical Equipment
Y3	58	None	NA	0%	Undisturbed by Mechanical Equipment
Z	14	Past Intermediate Harvest	1989	1%	Indistinct skid trails
BB	110	Past Regeneration Harvest	No Records	8%	Reusable skid trails
CC	42	Past Sanitation Salvage Harvest	1985	2%	Reusable skid trails
DD	98	Past Intermediate Harvest	1970s, 1980s	1%	Reusable skid trails
EE	36	Salvage and Regeneration Harvest	1979, 1985	0%	Indistinct skid trails
FF	67	Past Sanitation Salvage Harvest	1985	0%	Indistinct skid trails
GG	41	Past Sanitation Salvage Harvest	2000	2%	Reusable skid trails
HH	39	None	NA	0%	Undisturbed by Mechanical Equipment

Trends

Soil quality in the project area is trending upward. Past activities occurred 7 to 50 years ago. Since the completion of the previous projects, soil quality has improved by means of soil organism activity, root growth, freeze-thaw and wet-dry cycles, all of which are natural process that break up compacted soils (Lull, 1959. p. 20 and 21). Organic matter is continually being added to the soil surface and is being incorporated into the upper soil layers. Vegetation growing on the disturbed soils and organic matter added by the vegetation have reduced or eliminated erosion on bare soils. Erosion is further reduced by the gentle slopes in the project area.

The pre-harvest surveys of the proposed units show that some past disturbances such as skid trails are no longer detrimentally disturbed or are only slightly so; indicating that they are recovering and soil quality is trending upward (project file, section O).

Soils and Landtypes

The potential soil productivity for undisturbed soils is provided in Table 3-73. The ratings are relative to other Landtypes within the Flathead National Forest. This information is from the Soil Survey Report for the Flathead National Forest (1998).

Table 3-73. Soil Characteristics

Proposed Unit	Landtype and Soil	Productivity	Surface Soil Erosion Rating	Defining Characteristics
A	28-7/10-2	Moderate	Moderate	Sandy Textures
B	26J-7	High	Moderate	Sandy Loam Textures
C	27-7/28-7	Moderate	Moderate	Sandy Textures
D	28-7/27-7	Moderate	Moderate	Sandy Textures
E	28-7/27-7	Moderate	Moderate	Sandy Textures
F	27-7	Moderate	Moderate	Sandy Textures
G	26C-8/26C-9	High	Moderate	Silty Textures
H	27-7	Moderate	Moderate	Sandy Textures
I	27-7/26C-8	Moderate/High	Moderate	Sandy and Silty Textures
J	27-7/26C-8	Moderate/High	Moderate	Sandy and Silty Textures
K	27-7	Moderate	Moderate	Sandy Textures
L	27-7/26J-7/14-2	Moderate/High	Moderate	Sandy and Sandy Loam Textures
M	26J-7	High	Moderate	Sandy Loam Textures
N	14-2	High	Moderate	Sensitive when wet
O	26J-7/27-7	High	Moderate	Sandy and Sandy Loam Textures
P	26J-8	High	Moderate	Sandy Loam Textures
Q	26J-7/27-7	High	Moderate	Sandy and Sandy Loam Textures

Proposed Unit	Landtype and Soil	Productivity	Surface Soil Erosion Rating	Defining Characteristics
R	26J-7	High	Moderate	Sandy Loam Textures
S	26C-7	High	Moderate	Silty Textures
T	26C-7	High	Moderate	Silty Textures
U	26J-7	High	Moderate	Sandy Loam Textures
V	26J-7	High	Moderate	Sandy Loam Textures
W	26C-7	High	Moderate	Silty Textures
X	26G-7	Moderate	Moderate	Silty Textures
Y	26G-7	Moderate	Moderate	Silty Textures
Z	26G-7	Moderate	Moderate	Silty Textures
AA	26G-7	Moderate	Moderate	Silty Textures
BB	26G-7	Moderate	Moderate	Silty Textures
CC	26C-7&8	High	Moderate	Silty Textures
DD	26C-7&8	High	Moderate	Silty Textures
EE	26G-7	High	Moderate	Silty Textures
FF	26C-7&8	High	Moderate	Silty Textures
GG	27-7/26C-8	Moderate/High	Moderate	Sandy and Silty Textures
HH	26C-7	High	Moderate	Silty Textures
4A	27-7	Moderate	Moderate	Sandy Textures
4B	27-7	Moderate	Moderate	Sandy Textures
4C	26C-8	High	Moderate	Silty Textures
4D	27-7	Moderate	Moderate	Sandy Textures
4E	27-7	Moderate	Moderate	Sandy Textures
4F	27-7	Moderate	Moderate	Sandy Textures
4G	26C-7	High	Moderate	Silty Textures
4H	26C-7	High	Moderate	Silty Textures
4I	26C-8	High	Moderate	Silty Textures
4J	26C-7	High	Moderate	Silty Textures
4K	26C-7	High	Moderate	Silty Textures
4L	26C-7/27-7	Moderate/High	Moderate	Sandy and Silty Textures
4M	26C-7	High	Moderate	Silty Textures
4N	26C-8	High	Moderate	Silty Textures
4P	26C-7	High	Moderate	Silty Textures
4Q	26C-7	High	Moderate	Silty Textures
4R	26J-8	High	Moderate	Sandy Loam Textures

Sensitive Soils

Sensitive soils contain an excess of soil moisture either yearlong or on a seasonal basis. Disturbance on sensitive soils can lead to overland flow, soil erosion or loss of soil productivity. Unit N and a portion of Unit L are on a landtype (14-2) that is rated as sensitive (in spring and times of heavy precipitation).

Erosion Risk

The erosion risk for all the soils is moderate because of the relatively gentle slopes and the presence of a volcanic ash surface soil, which has a very high ability to move water into and through the soil. Runoff from these soils is uncommon.

Productivity

Productivity of soils formed in glacial till (Landtype 26) and lacustrine material (Landtype 14) is high because they are deep and provide adequate plant available nutrients and water. Soils in Landtype 27 have moderate productivity because they are sandy and hold fewer nutrients and less water than the other soils in the analysis area. However, those sandy soils have excellent rooting depth, are well drained and are not easily compacted. If compaction does occur it can increase their ability to provide plants with water.

A landtype map, based on the detailed investigation conducted in the late 1980s, is located in the project file, section O. The soils in the project area are described in the updated landtype report for the Flathead National Forest (Martinson and Basko 1998). Landtypes are the basis for the soil analysis. All soils are classified according to the system of Soil Taxonomy, a system used to classify soils according to their limitations that affect specific practical purposes. Classification of soils allows them to be grouped to permit the largest number and the most precise predictions possible about responses to use and management (USDA Natural Resources Conservation Service, 1999). In other words, the monitoring results from one taxonomic unit can be related to other similar taxonomic units.

Most soils on the Flathead National Forest, including all of those within the project area, have a surface that formed in volcanic ash material and thus are similarly classified. Most monitoring on the Flathead National Forest has occurred on soils that have a volcanic ash surface. Thus there are a large number of both quantitative density measurements and qualitative ratings that relate to the soils in the project area. This information has two valuable implications; first, we can estimate the amount of detrimental soil disturbance that exists from past management activities by doing transects and observing the amount of visible detrimental disturbance present and; second, we can estimate the amount of detrimental soil disturbance to expect from proposed management activities on given soil types and thus estimate the effects on the soil resource.

It is important to consider that not all soil disturbances are detrimental disturbances. Our monitoring suggests that some soil disturbances create bulk density below the levels that inhibit root growth (project file, section O). Research by Powers and others (2005) showed that coarse textured soils increased in production capacity with compaction because it increased their water holding capacity. They also noted that increases in bulk density were not reflected in site production if an understory was absent. In other words, reducing competition from forbs, brush and trees can leave more abundant resources for the remaining vegetation, even if soil bulk density increases.

Environmental Consequences

No significant issues related to soils were identified (refer to Chapter 2). The following Effects Indicators were used to focus the soils analysis and disclose relevant environmental effects:

- Soil productivity and soil erosion

The analysis of effects for soils assumes that all of the practices outlined in Chapter 2, Design Criteria Common to the All Alternatives, would be implemented and would be effective. The analysis will show the expected amount of soil disturbance resulting from implementation of the alternatives, and will also describe the risk that the expected amount of disturbance would be exceeded.

The soil analysis process is described in the Soil Analysis Guideline contained in the project file, section O. Direct, indirect and cumulative effects are discussed in terms of the activity areas. The Forest Service Handbook FSH 2509.18-2003-1 (see project file, section O) defines an activity area as a land area affected by a management activity to which soil quality standards are applied. An example is a harvest unit within a proposed timber sale.

The soils analysis is based on the current soil condition and analyzes the soil effects caused by implementation of the proposed management activities. Soil effects are a result of detrimental soil disturbances. Detrimental disturbances are defined in Forest Service Manual FSM R-1 Supplement No. 2500-99-1 (see project file, section O) as the condition where established soil quality standards are not met and the result is a change in soil quality. This Handbook also states that at least 85 percent of an activity area be maintained in satisfactory soil conditions.

The Handbook defines the Regional soil quality guidelines in terms of detrimental soil disturbance, which includes:

- Compaction
- Rutting
- Displacement
- Severely-burned Soil
- Surface Erosion
- Soil Mass Movement (Mass Failure)

<u>Mass Failures</u>

The proposed mechanized treatments are planned for a landscape with slopes less than 30 percent, which greatly reduces the risk of mass failures. No historic mass failures are mapped within the landtype/soil mapping for the project area. This lack of historic failures suggests that the area has a low mass failure risk. Implementation of road best management practices (BMPs) associated with this project would reduce concentrations of road surface drainage, thereby reducing the risk of mass failures associated with road drainage. Because mass failures are not a part of the landscape in the project area and because the area is at low risk for mass failure, they will not be discussed further.

Detrimental soil disturbances are the basis for the effects analysis of the Red Whale Project. However, not all soil disturbances have a detrimental effect on soil productivity. For example, loss of less than one inch of topsoil over less than 100 square feet is not a detrimental soil disturbance nor is light compaction that causes less than a 15 percent increase in bulk density or that does not elevate bulk density to levels that impede root growth (See Forest Service Manual FSM R-1 Supplement No. 2500-99-1 in the project file, section O.

Direct and Indirect Effects of Alternative 1 (No Action)

Alternative 1 provides a baseline to evaluate the effects of the action alternatives. The effects on soils are discussed as changes over time on soil productivity and soil erosion.

Soil Productivity

Alternative 1 would not cause short-term effects on the soil resource over and above the existing condition. No additional thinning, fuels reduction, prescribed burning, or road management activities would disrupt the natural soil processes.

Physical Soil Disturbances

Alternative 1 would not cause soil compaction, rutting, puddling, or soil displacement. Soils that are undisturbed would remain so. Soil productivity in areas where past timber management compacted soils would slowly improve as plant roots, soil organisms, and freeze-thaw events loosen the soil. Most soil disturbances would recover after 70 years (Gonsior 1983, p. 13-16). Sites that are slightly compacted would recover in fewer than 70 years. Displaced, rutted and puddled soils would have reduced productivity for a longer time than compacted soils.

Organic Matter

With implementation of Alternative 1, all standing dead trees would eventually fall over and contribute coarse woody debris. Needles and branches would remain on the site and fall to the ground. Soil organisms would decompose the organic materials thus adding humus to the soil. Nutrients associated with this material would slowly become available for plant growth. As the tree canopies close in and shade the soil surface, decomposition rates would slow, allowing organic matter and nutrients to accumulate on the soil surface. This process would continue until another major disturbance such as fire or a windstorm opens the tree canopy and speeds up the recycling process again.

An intense wildfire is a possibility at some time in the future. This event could reduce the amount of organic matter and associated nutrients on the site. This change would be temporary. Historically, in the Flathead National Forest forests grow back after wildfires.

Soil Organisms

Microorganism populations would fluctuate with the changes in the microclimate and the organic matter on the soil surface. These changes would be in response to the changing vegetation as a

result of natural events such as fire, insect, and disease. The changes would be temporary because of the mobility of soil organisms.

Soil Erosion

Alternative 1 would allow any current soil erosion to decrease as vegetation returns to soils that lack plant cover. Wildland fires could cause a short-term increase in soil erosion. Soil erosion rates would fluctuate with natural changes in vegetation**.**

Direct and Indirect Effects of Alternatives 2, 3, and 4

Soil Productivity

The objective of soil management is to reduce detrimental soil disturbance by limiting the area used for skid trails and landings and by implementing timing and equipment requirements (Soil design features in Chapter 2) that have the potential to reduce the amount and degree impacts on the skid trails.

Physical Soil Characteristics

All direct effects on soil physical characteristics would occur within the boundaries of the proposed activity areas. More specifically, most detrimental effects would be concentrated on the skid trails, temporary roads and landings. Reduced productivity is caused by detrimental soil disturbances such as soil compaction, displacement, rutting, or soil erosion. The proposed treatment areas would be harvested using designated trails and landings that are laid out to occupy less than 15 percent of the activity unit. Minimizing the area occupied by landings and skid trails to reduce the detrimental effects on soil productivity from changes in physical soil properties is recommended in several papers (Garland, 1997, Williamson and Nielson 2000, p. 1202, Deborah Page-Dumroese, 2004).

The proposed treatment areas would be harvested using designated trails and landings that are laid out to occupy less than 15 percent of the activity unit. A mathematical calculation in the project record demonstrates that spacing skid trails 75 and 100 feet apart cause detrimental disturbance on less than 15 percent of the activity area (project file, section O). In addition, Garland (1997) noted in a paper on minimizing soil effects from timber harvest that designated skid trails spaced 100 feet apart impact 11 percent of the harvest area. Monitoring of soil conditions on the Flathead National Forest after timber harvest showed that we consistently have less than 15 percent detrimental soil disturbance from a variety of ground based operations that use designated skid trails (project file, section O).

In addition to using designated skid trails and landings, there is a potential to further reduce soil effects by to the extent possible, operating equipment on skid trails when the soils are drier than field moisture capacity. Startsev and McNabb (2001), and McNabb and others (2001) found that soil compaction is reduced when soils are drier than field capacity. Williamson and Nielson (2000) noted that rutting and puddling are most often associated with logging on soils that are wet. Soil moisture monitoring on the Flathead National Forest showed that soils are drier than

field capacity during the summer dry period which begins in early summer and often lasts through October (see project file, section O). Most summer logging would occur when soils are drier than field capacity. Operating on low soil moisture conditions has the potential to reduce the detrimental disturbance on skid trails. Thus the area with detrimental disturbance has potential to be less than the area of skid trails and landings.

Winter logging under the proper conditions would cause fewer soil impacts than summer logging. Lull, (1959), mentioned over snow yarding as a means of reducing soil compaction. Williams, (1992) found that logging with snow cover, frozen ground conditions and designated skid trails caused no more runoff and sediment than did non-harvested sites, indicating a lack of soil disturbance such as rutting and puddling. A monitoring report for the Moose Fire Salvage Project (Collins, 2003) on soils near to and similar to those in the project area, found that winter logging on severely burned sites resulted in detrimental soil disturbance levels below 15 percent. One must consider that the burned areas Collins monitored were more susceptible to soil disturbance than unburned sites like those in the Red Whale Project Area. Monitoring results from winter logging on the Half Moon Timber Sale, Moose Fire Salvage (called the Glacier View and Big Creek Salvage Timber Sales: Soil Disturbance Survey and Report) and the Swaney Fire Salvage projects are in the project file, section O. These sales all had less than 15 percent detrimental soil disturbance.

Winter logging is required on all or portions of Units J, BB, 4B and 4E, is likely to occur on Unit F, and is an option on other proposed units in this project. Where winter logging is used the amount of detrimental soil disturbance is expected to be less than when logged in summer. BB is the only unit that has a winter logging requirement to protect soils from cumulative effects. Unit BB has 8% existing detrimental soil disturbance, thus is at high risk of exceeding the soil quality standards. Logging under winter conditions will more likely meet the soil standards.

A thesis by Sang-Kyun Han (2006) that looked at the effects of cut to length harvesting systems showed that heavy slash (about 40 kg/m2) was effective for buffering the effect of equipment operation on the mineral soil. Thus if cut to length systems are used and heavy slash is maintained on the skid trails, the extent of detrimental effects could be reduced. The same thesis noted that cut to length harvesting systems, which require that equipment stay on designated skid trails, create detrimental soil disturbance on about 10 percent of the harvested area. Han-Sup Han and others (2006) noted that logging when soils are drier than field moisture capacity reduced the amount of compaction associated with cut to length logging. Monitoring on the Flathead National Forest Duck Bill timber sale showed that 8 units logged with a forwarder all met the soil quality standards with less than 15 percent detrimental soil disturbance (project file, section O).

All mechanical slash piling or fuel reduction would be accomplished with excavators, or other machines that are light on the ground. This method reduces the aerial extent of detrimental soil impacts from the site preparation activities (Land and Resource Management Plan Annual Monitoring Report, 1992, page 131-139). Excavators have been monitored on the Flathead Forest since the early 1990s. Approximately 200 bulk density samples were collected where excavators worked. Those samples showed that excavators had minor effects on soil bulk density. In addition, when they are used on slopes that are less than 45 percent, displacement of

the topsoil is rare. Several timber sale projects have been monitored on the Flathead National Forest. These projects displayed less than 15 percent detrimental soil disturbance from ground based logging on designated skid trails when followed by excavator site preparation or fuels reduction (see project file, section O). Chippers mounted on tracked equipment similar to excavators would create soil effects similar to an excavator.

Summary. Both literature and local monitoring results indicates that we can meet the regional soil quality standards by using designated skid trails that occupy less than 15 percent of the harvest area. Additional protection of the soil resource would be afforded by operating ground based equipment when soils are dry; by operating in winter on snow or frozen soils; or by operating equipment on a dense slash mat. Cut to length harvesting also meets the regional soil quality standards as indicated by both literature and local monitoring. Excavator piling was monitored on the Flathead National Forest and caused few detrimental impacts. When excavator piling was used in combination with ground based logging systems the Region 1 soil standards were met. Unit BB would be winter logged to reduce the risk of cumulative effects from the proposed activities and the past activities. Sales that were monitored after winter logging met the soil quality standards with well below 15% detrimental soil disturbance.

Organic Matter and Nutrients

All of the proposed treatments are designed to reduce the amount of fuels and reduce the risk of wildfire. As a result the amount of organic matter and its associated nutrients would be reduced. The question is would enough organic matter be left on the site to insure soils promote the vigor and growth of the desired forest vegetation. In all cases, the amount of material left on site would be more than that left by a wildfire.

The total amount of nutrients on a site would likely be reduced where large amounts of organic matter would be removed. However, the plant available nutrients (those released from organic matter) would increase because sun and moisture would be increased in the treated stands, conditions that speed the breakdown of the remaining organic matter and the release of nutrients (Harvey and others, 1994). After project implementation competition between trees would be reduced because fewer trees would remain on the sites. This situation could result in more available nutrients and water for the remaining trees. Powers and others (2005) discussed this possibility and the result that the remaining trees have increased growth, vigor and disease resistance (refer also to Forest Vegetation analysis in Chapter 3).

Whole Tree Yarding. Ground based timber harvests that utilize whole tree yarding have the highest risk of reducing organic matter and affecting nutrient content of the site. In whole tree yarding, the entire tree including the braches and needles, minus those that break off when the tree falls to the ground, are taken to the landing. At the landing, the branches and needles are trimmed off the tree and put into a pile. This process can remove a large amount of organic material and associated nutrients from the activity area. However, the effect on the ground and on productivity depends on the inherent productivity of the soil, how much organic matter is left behind and whether it is enough to provide what the next forest requires to grow and be healthy. The proposed units all have high or moderate soil productivity (Table 3-74). All soils are deep (40 inches or more) and consist of an ash surface overlying glacial till deposits. Based on

observations of similar treatments on the Flathead National Forest, the sites will continue to grow native forest vegetation after treatment is completed.

One must also consider that the nutrients in the organic matter are not the only nutrients available to the forest vegetation. As the soils weather the nutrients they release are stored and made available to plants. Jurgenson, and others (1981) studied logging followed by low severity slash burning in northwestern Montana. The authors concluded there would be no long-term depletion of nitrogen reserves because lost nitrogen would be more than replenished by inputs from precipitation and by biological nitrogen fixation over a rotation of 100 to 150 years, indicating losses of nutrients associated with organic matter are temporary changes.

Harvey and others (1994) state that it is most difficult to resolve the loss of nutrients on sites with high fire potential. One potential result of this proposed project would be to reduce the risk of wildland fire by reducing the amount of fuels within the activity areas and by reducing the spacing of the remaining trees. More nutrients and organic matter would remain on all these sites after treatment than compared to a similar site burned by a severe wildfire.

All harvest prescriptions would leave a portion of the existing stand on the site. The proposed treatments are described in detail within Chapter 2 of this EA and in the Forest Vegetation section of this chapter. Timber management that leaves trees on the ground also leaves nutrients on the site for sustaining the future forest.

The patch seed tree harvests would remove the highest amount of trees of all the proposed activities and thus would have the least amount of soil nutrients for the future stand of trees. These units are also the units most likely to be logged with whole tree yarding. Table 3-74 displays the acres of each treatment by alternative with a rating for risk from removing organic matter.

Table 3-74. Acres of Organic Matter Reduction by Alternative.

Treatment	Approximate Number of Trees Left after Treatment	Alternative 1 (Acres)	Alternative 2 (Acres)	Alternative 3 (Acres)	Alternative 4 (Acres)	Amount of Organic Removal
Light Understory Thin	100 to 140	0	92	0	92	Low
Patch Seedtree	15 to 20	0	124	75	173	High
Thin Small and Medium Trees	70 to 110	0	839	431	1276	Low

Treatment	Approximate Number of Trees Left after Treatment	Alternative 1 (Acres)	Alternative 2 (Acres)	Alternative 3 (Acres)	Alternative 4 (Acres)	Amount of Organic Removal
Thin Sapling and Small Trees	70 to 130	0	451	327	585	Low
Thin Sapling	100 to 500	0	414	94	1299	Low
Thin 30% of the Sapling Area	100 to 500	0	118	0	118	Low

The patch seedtree harvest units (Units B, C, Q, R, FF, HH, 4A) would remove the most organic material. Therefore, if any further treatment is required after harvest to reduce fuel loads, it would be accomplished by chipping, which leaves the material on the ground, or by piling after the material has lain on the ground for a wet season. Chipping requires no delay.

In order to reduce the loss of nutrients in seed tree areas, fuels reduction in these units where chipping is not the implementation method would be delayed for one wet season. This design feature would provide time for nutrients to leach from the organic debris before it is removed from the site, as discussed by Garrison and Moore (1998 p. 33 and 34).

Excavator Piling. Excavator piling may be used for some of the mechanical fuels reduction work. Thus, the amount of organic matter on the site would be reduced. However, a variety of all organic matter would remain on the site after project implementation.

Chipping. Chipping is an option for reducing the amount of fuels on the activity areas after treatments are complete. Chipping is carried out by equipment similar to an excavator, thus would have similar effects on the soil. In addition, chipping leaves all the treated organic material on the soil surface where it contributes to the nutrient supply for the future forest.

Hand Treatments. Some sapling units could be thinned by hand. In these same units, some organic matter would be put into small hand piles and burned. Because the hand piles are small, the amount of area disturbed by burning them would be less than 10 feet in diameter and they would burn with low amounts of heat and smoke. The amount of nutrients lost during burning would be minor. The ash where the hand piles are burned would contain nutrients available to nearby vegetation.

The amount of heat generated by small hand piles is less than that created when large piles burn. As a result, the amount of nutrients that go up with the smoke would be minor. As discussed by DeBano, et al. (1999, p.112) the effect would not likely be adverse to soil productivity because nutrient replenishment mechanisms remain on the site. These mechanisms include the presence of nitrogen fixing organisms, both plant and microorganisms, organic matter that is left on the

soil surface, and living vegetation on the site.

Vegetation and soil microorganisms remaining in the harvested sites would use and store nutrients released from organic matter, preventing nutrients from leaching from the site. The amount of nutrients leached as a result of the proposed project would be less than the loss after wildland fires because of the presence of living trees, shrubs, grasses, and forbs left in the treatment units.

Summary. Most proposed units would retain 70 to 130 live trees per acre, which would retain a large amount of nutrients on site. In addition, most of the living forbs, grasses and shrubs would remain along with much of the material on the ground. In the patch seed tree units, which have the highest risk of losing organic matter, any additional treatment of fuels would be delayed one wet season to allow the nutrients to leach from the needles and fine branches. All of the units would have an active microorganism-rich organic layer on the soil surface.

Soil Organisms

Jurgenson and others (1977) note that after a fire, soil micro-flora recover quite rapidly, frequently to levels greater than the original. Borchers and Perry (1990) discussed the important role that less disturbed areas of soil play in inoculating soil that lacks or has reduced numbers of soil microorganisms. They state that unburned areas within burns, adjacent undisturbed areas, large woody debris, and soils that have only minor amounts of disturbance contain propagules for fungi, bacteria and other soil organisms and that these propagules are dispersed by wind, animals, and other agents. The variety of organic matter left on the proposed harvest areas would benefit soil organisms by providing substrate and habitat for soil them to survive in. All alternatives would leave both dead and live trees. All alternatives and all proposed activity areas would have less than 15 percent of the area detrimentally disturbed. Many areas would be undisturbed by equipment. These areas would be a source of soil organism propagule for disturbed sites in the project area. The amounts of live and dead trees to be left in the proposed harvest areas are described in the vegetation analysis.

Soil compaction, puddling, rutting, and displacement reduce the ability of soils to exchange oxygen and carbon dioxide thus affecting the ability of soil organisms to survive. However, favorable habitat for soil organisms would be maintained because all proposed harvest areas would be designed to reduce soil disturbance and meet the Regional soil guidelines.

Summary. Because the amount of detrimental physical soil changes would be minimized, and because organic matter in various forms would remain on the proposed units, the effects to soil microorganisms would be minor. Soil microorganisms are mobile. They can move from undisturbed sites to disturbed sites. Thus their loss is not permanent. A variety of organic matter will remain on all sites, including living trees and other forest vegetation. In addition, the organic layer on the soil surface will be retained over at least 85 percent of the area, providing habitat and nutrients for soil microorganisms.

Effects from Prescribed Burn Units. Several units would be burned to improve wildlife habitat. No other treatment would occur in these units. The proposed burning would occur under

conditions that promote light or moderate burn temperatures, which would keep the soil effects within or less than the natural range of variability resulting from wildfire. These less severe burn conditions would preserve the productive potential of the soils. The amount of nutrients available to plants would increase as a result of the burning. The proposed burn conditions would allow many plants to quickly return to the burned sites from unburned roots and seeds in the soil. Vegetation that returns after the fire would take up the available nutrients, keeping them on the site and reducing the risk of nutrients leaching beyond the reach of plants. Native forest vegetation would remain on the site, including some of the existing trees and new trees.

Soil Erosion

Soil erosion would be unlikely to occur as a result of the hand treatments. If thinning slash is lopped and scattered it would add cover to the soil surface, reducing the risk of erosion. Burning hand piles would create small round shaped areas of disturbance that would be unlikely to erode because slopes are gentle and the disturbance is of small extent. If the hand piles are simple left on the site, there would be no risk of soil erosion.

Mechanical equipment operation would be most likely to cause soil erosion. Where there is a risk of soil erosion, it would be minimized by implementing the following management practices: reducing the area where equipment operates, locating landings on relatively flat ground that can be drained, locating skid trails on slopes less than 35 percent that have soils with a low or moderate erosion hazard and by using erosion control features such as water bars, planting vegetation, and placing slash on disturbed soils. Management activities that leave organic matter on the soil surface also reduce soil erosion. Using these management tools in the proposed project would minimize soil erosion. Detrimental effects caused by soil erosion are long term. The soil lost by erosion can take thousands of years to re-form.

Several runs of a Water Erosion Prediction Project (WEPP) model indicate that the amount of soil erosion would most likely be small from the low intensity burns (refer to analysis in Hydrology section of this chapter). Erosion would not occur if rains were gentle in the two years following the burns. If severe storms with a return interval of 30 years occurred (a 17 percent chance this could occur), soil erosion could be as high as 11 tons per acre, which is equivalent to about 0.1 inch per square foot of area. If intense rains do not occur, erosion would be much less or non-existent depending on multiple variables such as the amount of cover left on the site, which included both vegetation and surface rocks, the intensity of the fire, which is planned to be light or moderate, and the slope which varies from flat to 60 percent. The WEPP runs are included in the project file, section O.

Duration of Direct and Indirect Effects

Displacement, the loss of topsoil, is a long term and perhaps a permanent loss of soil productivity. However, the management practices outlined in the design features would reduce the amount of displacement and all other detrimental impacts, to within the Region 1 guidelines.

Compaction lasts 10 to 70 years (Gonsior 1983, p. 13 - 16). Monitoring of 30 year old activities within this project area showed less than 4 percent detrimental soil disturbance now, indicating recovery of the compacted soils has occurred.

Reductions in organic matter content recover quickly as vegetation grows. Organic debris accumulates on the surface and roots grow and are decomposed in the soil. These organic materials break down and release nutrients and improve the quality of the soil by improving its structure and reducing compaction and other detrimental soil disturbances. Loss of organic matter is a short term change lasting about 10 years once vegetation returns to the soil.

Light and moderate burned areas have minor effects well within the natural range of variability for wildfire. Areas burned under conditions that produce light or moderate burn severity would vegetate quickly because they still have viable seeds or roots that could produce more plants and because the soil contains a complement of microorganisms and nutrients (Ryan and Noste, 1983, p. 232).

Changes in soil micro organisms are not permanent. Recovery would occur as soon as organic matter is present in the soil, which could be immediately after the proposed management is carried out.

Soil erosion would be controlled through the use of erosion control measures. In addition, bare soils would either be vegetated with native seed or would naturally recover as vegetation returns to the disturbed sites. Any erosion that occurs would be short lived, most likely occurring during the time between the soil disturbance and the implementation of erosion control measures.

Other Literature Mentioned in Public Comment

Numerous studies have suggested that most soil compaction occurs in the first few passes. These include studies by Cullen and others (1991), Page-Dumroese (1993), Brais and Camire (1997) and Williamson and Neilsen (2000). Page-Dumroese (1993) also cited other studies that indicated similar results. However, local monitoring results mentioned elsewhere in this document indicate that the amount of detrimental soil disturbance caused when using designated skid trails and other design features is within and can be less than the 15 percent specified in the regional soil quality standards. In addition, monitoring of past activities within the project area indicates that many skid trails that are 30 years old or more are recovering. Pre-assessment monitoring of proposed treatment units showed no more than 3 percent existing detrimental soil disturbance, even though many of these areas were harvested in the past (project file, section O).

Kuennen, Edson, and Tolle, (1979.) found compaction at depths up to 16 inches in the soil. Concern was expressed that the Flathead National Forest lacks proper monitoring to know if we have compaction. We have taken hundreds of bulk density samples at several depths in the soil profile (see project file, section O) but we have concentrated on the ash surface layer. Recent papers discuss the importance of the volcanic ash surface layer in maintaining the productivity of forests in the Northwest (Daley-Lauresen 2007, McDonald and Wilson, 2007 and Craigg and Howes 2007). Based on these studies and others, we use the bulk density of the ash surface layer as an indication of overall soil quality after treatment.

Cumulative Effects

Cumulative effects occur when past present or foreseeable activities overlap in both time and space with the proposed activities. Thus, cumulative effects are limited to the activity area where the proposed activities would occur. In other words, cumulative effects would occur only where proposed activities would occur where previous management has affected soil conditions. Activities outside of the locations of proposed management are not subject to cumulative effects because they do not overlap spatially with the lands being proposed for management in the Red Whale Project. Soil effects do not extend off of the piece of ground where they occur.

The risks of cumulative effects were assessed within each proposed activity area. Cumulative effects consist of the impacts from all past, present, future and proposed activities that overlap in time and space with the proposed project. All units except those specific to Alternative 4, were reviewed on the ground to quantify and qualify the effects from past timber harvest and determine if existing levels of detrimental soil disturbance exceed the Regional soil quality guides. The estimated cumulative effects for each activity area from implementation of an action alternative are in Table 3-75. The past activities and their effect on soils are briefly summarized in Table 3-76.

Table 3-75. Cumulative Effects Summary

Unit	Alternative 2 Treated Acres	Alternative 3 Treated Acres	Alternative 4 Treated Acres	Treatment Method	Winter Logging Restriction	Fuels Treatment [1]	% Existing Detrimental Disturbance	% Project Disturbance [3]	% Cumulative Disturbance
A	5	0	5	Ground Mechanized		*	0%	10 to 14%	10 to 14%
B	16	16	16	Ground Mechanized		*	0%	10 to 14%	10 to 14%
C	17	5	17	Ground Mechanized		*	0%	10 to 14%	10 to 14%
D	108	70	108	Ground Mechanized		*	0%	10 to 14%	10 to 14%
E	38	30	38	Ground Mechanized		*	0%	10 to 14%	10 to 14%
F	61	25	61	Ground Mechanized	X Depending on access	*	0%	5 to 10%	10 to 14%
G	196	196	196	Ground Mechanized		*	0%	10 to 14%	10 to 14%
H	78	33	78	Ground Mechanized		*	1%	10 to 14%	11 to 15%
I	87	8	87	Ground Mechanized		*	0%	10 to 14%	10 to 14%
J	164	48	164	Ground Mechanized	X	*	1%	5 to 10%	11 to 15%
K	59	0	59	Ground Mechanized		*	1%	10 to 14%	11 to 15%
L	169	91	169	Ground Mechanized		*	2%	10 to 14%	12 to 16%
M	123	25	123	Ground Mechanized		*	0%	10 to 14%	10 to 14%
N	44	0	44	Ground Mechanized		*	0%	10 to 14%	10 to 14%

Unit	Alternative 2 Treated Acres	Alternative 3 Treated Acres	Alternative 4 Treated Acres	Treatment Method	Winter Logging Restriction	Fuels Treatment [1]	% Existing Detrimental Disturbance	% Project Disturbance [3]	% Cumulative Disturbance
O	45	0	45	Ground Mechanized		*	1%	10 to 14%	11 to 15%
P	82	34	82	Ground Mechanized		*	0%	10 to 14%	10 to 14%
Q	37	37	37	Ground Mechanized		*	0%	10 to 14%	10 to 14%
R	28	28	28	Ground Mechanized		*	0%	10 to 14%	10 to 14%
S1	12	0	12	Ground Mechanized		*	0%	10 to 14%	10 to 14%
S2	7	0	7	Ground Mechanized		*	0%	10 to 14%	10 to 14%
S3	40	0	40	Ground Mechanized		*	0%	10 to 14%	10 to 14%
S4	46	46	46	Ground Mechanized		*	4%	10 to 14%	14 to 18%
T1	10	0	10	Ground Mechanized		*	0%	10 to 14%	10 to 14%
T2	17	0	17	Ground Mechanized		*	0%	10 to 14%	10 to 14%
T2	10	0	10	Ground Mechanized		*	0%	10 to 14%	10 to 14%
T3	85	0	85	Ground Mechanized		*	0%	10 to 14%	10 to 14%
U	9	0	9	Ground Mechanized		*	0%	10 to 14%	10 to 14%
V	11	0	11	Ground Mechanized		*	0%	10 to 14%	10 to 14%
W	14	0	14	Ground Mechanized		*	0%	10 to 14%	10 to 14%

Unit	Alternative 2 Treated Acres	Alternative 3 Treated Acres	Alternative 4 Treated Acres	Treatment Method	Winter Logging Restriction	Fuels Treatment [1]	% Existing Detrimental Disturbance	% Project Disturbance [3]	% Cumulative Disturbance
X	34	0	34	Ground Mechanized		*	1%	10 to 14%	11 to 15%
Y1	16	0	16	Ground Mechanized		*	0%	10 to 14%	10 to 14%
Y2	26	0	26	Ground Mechanized		*	2%	10 to 14%	12 to 16%
Y3	17	0	17	Ground Mechanized		*	0%	10 to 14%	10 to 14%
Z	14	0	14	Ground Mechanized		*	1%	10 to 14%	11 to 15%
BB	110	110	110	Ground Mechanized	X For soil reasons	*	8%	5 to 10%	13 to 18%
CC	42	42	42	Ground Mechanized		*	2%	10 to 14%	12 to 16%
DD	98	0	98	Ground Mechanized		*	1%	10 to 14%	11 to 15%
EE	36	36	36	Ground Mechanized		*	0%	10 to 14%	10 to 14%
FF	6	6	6	Ground Mechanized		*	0%	10 to 14%	10 to 14%
GG	41	21	41	Ground Mechanized		*	2%	10 to 14%	12 to 16%
HH	20	20	20	Ground Mechanized		*	0%	10 to 14%	10 to 14%
4A[2]	0	0	49	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4B[2]	0	0	102	Ground Mechanized	X	*	Unknown[2]	5 to 10%	Unknown
4C[2]	0	0	76	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown

Unit	Alternative 2 Treated Acres	Alternative 3 Treated Acres	Alternative 4 Treated Acres	Treatment Method	Winter Logging Restriction	Fuels Treatment [1]	% Existing Detrimental Disturbance	% Project Disturbance [3]	% Cumulative Disturbance
4D[2]	0	0	119	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4E[2]	0	0	80	Ground Mechanized	X	*	Unknown[2]	5 to 10%	Unknown
4F[2]	0	0	48	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4G[2]	0	0	13	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4H[2]	0	0	40	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4I[2]	0	0	289	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4J[2]	0	0	152	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4K[2]	0	0	20	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4L[2]	0	0	48	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4M[2]	0	0	78	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4N[2]	0	0	153	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4P[2]	0	0	134	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4Q[2]	0	0	100	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown
4R[2]	0	0	4	Ground Mechanized		*	Unknown[2]	10 to 14%	Unknown

[1] Fuels treatment would be accomplished by one of the following methods: whole tree yarding could be used to remove enough material so that no further equipment would be needed; or excess material could be chipped; or the material left on the ground or standing could be piled with an excavator and the piles burned. The effects from these activities are discussed in the Direct and Indirect Effects section of the soils analysis.

[2] Units beginning with the number 4 would occur only in Alternative 4. Field investigations have not occurred within these units. If Alternative 4 is selected and these units remain as part of Alternative 4, then an on ground check will be made to determine their existing condition. Any units that have an existing condition that currently exceeds the regional soil quality standards (more than 14% detrimental soil disturbance) would be dropped. If a unit has an existing condition of 6% to 14% detrimental disturbance, it would be recommended for winter logging to provide additional soil protection. Based on a preliminary GIS exercise, all units specific to Alternative 4 except 4K have had past activity. The effects are likely to be similar to the other proposed units (i.e. <3% existing detrimental disturbance) because the past treatments were similar in time and type of treatment.

[3] The results are presented as a possible range of effects. Monitoring would be done as described in Chapter 2. Implementing the design features discussed in Chapter 2 would likely reduce detrimental soil disturbance to less than 15 percent. This statement is based on two sources of information: First, several logging operations that utilized various skid trail spacings and various seasons of operation have been monitored. The reports from those projects indicated that as long as the skid trails were well laid out and older skid trails were reused, if they existed, less than 15 percent soil detrimental disturbance resulted.

Second, worksheets were included in the project file that displayed calculations of the amount of expected detrimental disturbance in an area based on the following assumptions: an average skid trail is about 10 feet wide and the spacing between skid trails was either 75 feet or 100 feet. Trails spaced 75 feet apart occupy 13.5 percent of a unit. Trails spaced 100 feet apart occupy 10 percent of a unit. Both figures are within the Regional Soil Quality Standards of 15 percent. The actual percent detrimental disturbance would depend on the amount of skid trails reused.

Unit Specific Discussion

Units BB would be winter logged to reduce the effects on soils caused by the proposed activities. It is likely it would meet the regional soil standards.

The sapling thin Units S4, X, Y2, and Z have low amounts of existing detrimental soil disturbance. Equipment used to treat these units would be light on the ground and would reuse existing skid trails to the extent possible, reducing the amount of additional soil disturbance. If material is removed from the units the effects would be less than for the commercial harvest activities because of the small material size (18 year old sapling stands). All applicable design features would be followed. It is likely they would meet the regional soil standards.

Units H, J, K, L, O, CC, DD, and GG also have low amounts of detrimental soil disturbance from past activities. Most of these units would remove commercial products and have equipment on the ground; they are potential sites for cumulative effects. Existing skid trails would be reused, reducing the amount of additional soil disturbance. All applicable design features would be followed. It is likely they would meet the regional soil standards.

Past Actions and Their Effects on Current Conditions.

Many of the proposed harvest units had evidence of past activities. Firewood cutting along roads has had minimal effects on soil productivity because it is carried out by hand and the fine branches and needles are left in the woods.

The proposed prescribed burn units have had no past disturbance. They are located above the existing road system and thus have not been subject to firewood cutting or any other activities. The burn units would not have cumulative effects.

There is no evidence of past or present domestic grazing within the borders of the project area.

Any off road vehicle use off of designated use areas would have been identified and accounted for during the field surveys, although none was identified in the field notes.

Alternative Comparison.

Table 3-76 displays the total acres of predicted detrimental soil disturbance caused by implementing the proposed activities. On a relative basis Alternative 3 would create the least detrimental soil disturbance because it treats the fewest acres. In addition, it drops Units Z, Y2, X, O and K, which have a risk, but are not guaranteed, to exceed the soil quality standards. However, all alternatives are designed to reduce the amount of detrimental soil disturbance by implementing the design features described in Chapter 2, with the intent of meeting the soil quality standards.

Table 3-76. Summary of Detrimental Soil Disturbance by Alternative

	Alternative 2	Alternative 3	Alternative 4
Total Acres Treatment	2078	927	3583
Existing Acres Detrimental Disturbance from Past Activities within Proposed Activity Areas	22	16	22 Plus an unknown amount from units specific to Alternative 4
Estimated Acres Detrimental Disturbance from Proposed Activities	174 to 244	83 to 122	333 to 481
Total Cumulative Detrimental Disturbance After Project Implementation	196 to 266	99 to 138	355 to 503

Contrasting Effects of Proposed Action with Past Actions.

The estimated level of detrimental disturbance from this proposed project is less than has occurred as a result of harvest activities in the past. During the past two decades, the level of concern for maintaining soil productivity has increased and along with this has come implementation of management practices that better protect the soil. These changes include the use of excavators instead of dozers for mechanical site preparation; cut to length yarding systems; use of designated skid trails; and operating when soils are dry or when winter conditions would protect soil productivity.

In addition, timber sales are audited for compliance with BMPs and are monitored to see that design features that reduce soil effects are implemented. Both of these practices produce better results than in the past.

Effects of Ongoing and Reasonably Foreseeable Activities.

The known ongoing and foreseeable activities would not overlap with the proposed action in both time and space. Specifically, their effects do not overlap in space. They occur outside of the proposed activity areas.

Combined Effects from Past, Proposed, Ongoing and Foreseeable Activities

Cumulative effects on soils are the combination of the existing detrimental disturbance from past activities combined with the estimated disturbance that would result from the proposed project. Unit BB has the highest amount of existing soil effects. Therefore, it would be winter logged to reduce additional impacts. With winter logging it is likely to meet the soil quality standards. The

total expected cumulative effects for each proposed activity area are shown in Table 3-75. The estimated cumulative effects range from 0 percent to 18 percent. The units with the highest risk of exceeding the regional soil standards are those that had past activities and still have some detrimental soils disturbance. Monitoring would emphasize the proposed activities that would remove merchantable trees with mechanized equipment from units with detrimental soil disturbance from past activity. If the cumulative effects exceed soil quality standards, then restoration would occur to move those units towards improved conditions.

Restoration activities to improve soil conditions would include lightly ripping heavily used skid trails and landings. The goal would be to reduce soil compaction and meet the direction provided in Region 1 Supplement 2500-99-1 (See Regulatory Framework and Consistency at the end of this section). Several studies discuss the effectiveness of ripping as a soil restoration activity. Studies cited by Froehlich and McNabb (1983) showed up to 39 percent improved seedling survival and growth after tilling compacted soils. The same study showed height growth gains of 8 to 73 percent.

A publication by Dick, et al. (1988) that found rehabilitation treatments of subsoiling (tilling) restored biological processes that were reduced by soil compaction. In general, tilling or scarifying a compacted soil improves productivity by reducing the resistance of soil to root penetration, and providing improved soil drainage and aeration to enhance seedling establishment and tree growth (Bulmer 1998, p 10 and 13) and improve the environment for soil organisms. The goal of soil restoration is to set the stage for the soil to begin the recovery process. Soil restoration is not an immediate result of ripping, planting, or any other activity.

New Road Construction

All action alternatives would construct 0.3 mile of new road that would occupy less than 1 acre of land. This road would not overlap in space or time with fuel reduction activities and thus would not cause cumulative effects. The soil quality standards do not apply to roads.

Regulatory Framework And Consistency

The soil analysis indicates that all alternatives and all activities proposed by the alternatives would meet the Region 1 Soil Quality Standards through the implementation of management practices outlined in Chapter 2 and restoration of landings and heavily used skid trails, if needed, to reduce the total amount of detrimental soil impacts. All Forest Plan management direction would be met by the proposed alternatives.

This page left intentionally blank.