SOILS

Introduction

This section discusses the existing condition and affected components of the soil resource, how past management activities have affected the soil resource, and the effects of implementing the alternatives. Soil components to be discussed in detail are soil productivity, soil erosion and mass failures.

Forest Service Handbook FSH 2509.18-2003-1 (USDA Forest Service, 2003), defines the Regional soil quality guidelines in terms of detrimental soil disturbance, which includes:

- *Compaction*. Compaction is detrimental when natural bulk density increases more than 15 percent.
- *Rutting*. Wheel ruts at least two inches deep in wet soils are detrimental.
- *Displacement.* Detrimental displacement is the removal of one or more inches (depth) of any surface soil horizon, usually the A horizon, from a continuous area greater than 100 square feet.
- *Severely-burned Soil*. Physical and biological changes to soil resulting from high-intensity burns of long duration are detrimental.
- *Surface Erosion*. Rills, gullies, pedestals, and soil deposition are all indicators of detrimental surface erosion.
- *Soil Mass Movement*. Any soil mass movement caused by management activities is detrimental.

Most detrimental soil disturbances are on existing or proposed landings and skid trails. These land uses are a part of the disturbed soils identified during monitoring of both existing condition and effects of project implementation. It is possible to have soil disturbances that are not detrimental. For example, loss of less than one inch of topsoil over less than 100 square feet is not a detrimental soil disturbance. Many areas of light soil disturbance have no or immeasurable affects on future soil productivity.

Analysis Area

The analysis area for soils encompasses all lands within the boundaries of the West Side Watersheds (173,347 acres). This analysis area was selected because all proposed management activities would occur within the Watersheds. A landtype map for the area is located in Exhibit H-1. The soils in the project area are described in the updated landtype report for the Flathead National Forest (Martinson and Basko 1998). The report is available at any District

Office or the Supervisor's Office in Kalispell. Soils in the project area have been rated for their sensitivity to management activities. All soils that are mapped as moderate or high burn severity are sensitive to management activities. Disturbance on these soils can lead to overland flow, soil erosion, or loss of soil productivity. In addition, certain landtypes within high precipitation zones are also sensitive. Sensitive soils tend to have too much water at some times of the year. Linear soil disturbances are likely to cause overland flow and associated erosion and sediment. Management practices and mitigation measures will be designed to protect sensitive soils based on the slope of the ground and the burn severity.

The effects analysis follows the process described in the Soil Analysis Guideline contained in Exhibit H-2. Cumulative effects are discussed in terms of both the analysis area, described above and activity areas. Activity areas are the designated cutting units where timber management would occur. They are a subset of the larger analysis area. The soils analysis is based on the amount of detrimental soil condition before and after the proposed management activities. Detrimental soil conditions are defined as the condition where established soil quality standards are not met and the result is a substantial change in soil quality (Forest Service Manual, R-1 Supplement No. 2500-99-1, 1999).

Information Sources

Definitions used in this analysis came from the Forest Service Handbook FSH 2509.18-2003-1 (USDA Forest Service, 2003) and the Forest Service Manual FSM 2500-99-1 (USDA Forest Service, 1999). The TSMRS database was used to compile a first evaluation of the proposed units that have had previous management activities. It was also used to estimate the existing condition of the analysis area. GIS coverage's were used to get the amount of roads, trails and other existing soil disturbances in the analysis area. Field observations were used in addition to the TSMRS queries to determine the existing condition of proposed units. Field data summary sheets are in Exhibit H-3. Field observations followed the methods described in S. W. Howes (2001). In addition, the results of monitoring various management activities on the Flathead National Forest were used as a basis for the effects analysis.

Affected Environment

Spatial Bounds: The West Side Reservoir Project area is the analysis area for determining the direct, indirect, and cumulative effects of the alternatives on the soil resource. The rationale for the selection of this analysis area is that the proposed management activities would not extend beyond the project area. The area within the proposed treatment units is considered the activity area; FSH 2509.18-2003-1 (USDA Forest Service, 2003) defines an activity area as a land area affected by a management activity to which soil quality standards are applied.

Temporal Bounds: Effects from activities that occurred in the 1950s and through the year 2004 are included in the soils analysis. Foreseeable activities planned through the year 2005, such as harvest and road building, are also included.

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

- Soil productivity
- Soil erosion
- Soil stability (mass failure)

Disturbances

Natural and human-related disturbances have affected the soils in the analysis area. Natural disturbances of the soil include glacial activity, floods, mass erosion, drought, insects, plant disease, and wildland fires. Natural disturbances can alter long-term soil conditions. The West Side Fire was the most recent natural disturbance in the analysis area; it will be discussed in detail.

Human disturbances have occurred in the analysis area for possibly hundreds of years. The extent and degree of human disturbance, however, has been most pronounced in recent times. Recent disturbances include such activities as road construction, timber harvest, prescribed fire, fire suppression, and recreational activities. Human disturbances can affect long-term soil productivity by committing areas to specific uses (e.g. roads), or disturbing the soil by causing compaction, rutting, puddling or displacement, or by accelerating erosion.

The Effects of Fire on Current Soil Condition

The primary means of discussing the post fire conditions of soils is burn severity, which was mapped following the West Side Fire (refer to Figure 3-1 through 3-4 and Table 3-76). Burn severity describes the fire-caused damage to the soil. It is a measure of the effects of fire on soil conditions including how water moves into and through the soil (hydrologic properties). Together with slope, burn severity influences the amount of soil erosion following a fire. Burn severity is discussed in depth in the Soils Report for the Burned Area Emergency Rehabilitation (BAER) project (Exhibit H-4). A map of soil burn severity ratings and unit location is located in (Exhibit H-5).

Burn severity classes are identified as low, moderate, or high. On low burn severity sites the duff layer is partially consumed by the fire and very little heating of the soil surface layer occurs. The fire does not affect the soil hydrologic properties. Many unburned roots and seeds that are in the surface soil will aid in vegetating the burned areas. Natural re-vegetation on these sites will occur quickly. Typically, unburned trees and shrubs are present and provide cover that reduces soil erosion. Management using ground-based equipment is unlikely to increase soil erosion over that of similar unburned sites.

The moderate burn severity sites have slightly altered surface soil structure, reduced numbers of fine roots, and less seed viability in the soil surface. Natural revegetation on these sites is slower than a low burn severity site. In most places the duff is reduced to a layer of charred litter. Hydrophobic soil conditions may occur under moderate burn severity sites, but are usually spotty and short-lived. Sites with moderate burn severity are more likely to lead to increased soil erosion if they are disturbed by ground based logging equipment or other disturbances. However, erosion control practices are effective on these sites and must be applied. These soils are also susceptible to physical disturbance caused by equipment.

High burn severity sites have modified surface soil properties. The surface soil structure has broken down, and a hydrophobic layer may be present. Soil conditions and a lack of organic litter or duff allows for raiSoil-impact erosion at the soil-air interface, reduced infiltration, and increase erosion and runoff. There are few viable roots or seeds in the upper several inches of the soil. The natural re-vegetation on these sites is slow. Soils on these sites are highly susceptible to erosion and physical soil disturbance, especially when ground based equipment operates on them. These soils require special mitigation measures and management practices to reduce soil erosion.

The potential for erosion is highest on the steep slopes that burned with a high burn severity.

Water Repellant (Hydrophobic) Soils

Soil can become water repellant following a fire. During the post fire field investigation last fall some of the high and moderate burn severity sites demonstrated water repellency. A discussion of hydrophobic soils is in the soils report portion of the BAER Report for the fire (Exhibit H-4). A study of hydrophobic soils on the Tally Lake Ranger District of the Flathead National Forest indicates that this condition is temporary on fine textured soils and will naturally decline as fall rains and melting snow wet the soil profile (DeByle 1973, page 86). Several site visits this spring and summer have shown that rains are now soaking into the soils and the soils is no longer hydrophobic.

Table 3-76. Burn severity acreage for the West Side Fire.

Burn Severity	Acres	Percent of Burned Area
Severe	421	1.4
Moderate	6722	22.4
Low	2600	8.7
Low/Unburned Mosaic	20,008	66.5
Unburned	296	1.0
Total	30,038	100

Fire and Soil Productivity

Fire alters soil properties including organic matter content and nutrient related processes. Many studies have shown leaching of soil nutrients, mainly nitrogen, following fires. Studies within the Flathead Basin have shown this occurs here. However, the local studies indicate that this was a short-term loss, usually diminishing within weeks of the fire (Spencer and Hauer 1990).

Fire alters nutrient cycling and soil productivity in several ways. Soil erosion caused by wildfire reduces soil productivity if it is severe and widespread. Nutrients, mainly nitrogen, are volatized during fires and leave the site with the smoke. At the same time, the ash that falls to the ground is rich in nutrients including nitrogen, that are taken up by the first plants that germinate or sprout. Severe fires that kill all the seeds and roots in the soil slow the establishment of vegetation. This condition increases the risk that nutrients, especially nitrogen, will leach beyond the presence of roots and find its way into ground water and streams (Debano et al. 1998, p 108-114).

Fire plays a natural role in balancing vegetation systems with site, soil, and climate (Harvey et al. 1994, page 43). Fire recycles stored carbon and nutrients back to the soil to be used again by the next generation of plants. Fire has been a part of the West Side ecosystem since the glaciers retreated some 10,000 years ago. Numerous wildfires have run their course in the West Side drainage and after each one vegetation has returned, demonstrating the resiliency of the soils.

Fire and Soil Erosion

As noted by Beschta et al. (1995) soils are vulnerable in a burned landscape. There will be areas of soil erosion within the burned areas that will persist until the sites re-vegetate or there are sufficient accumulations of organic materials on the soil surface. Areas of overland flow will occur where the amount of precipitation and/or snowmelt water exceeds the infiltration rate of the soil. If insufficient cover is present on these sites soil erosion will occur. However, there have been numerous fire cycles in this area since the glaciers melted 10,000 years ago. At times, large areas lacked vegetation and the soils were exposed to the erosive forces of rains, wind, and snowmelt. The current landscape in the West Side area shows little evidence that extensive erosion has occurred since the deposition of the volcanic ash layer 6600 years ago from the eruption of Mount Mazama in southwest Oregon. If numerous large erosion events had occurred one should see areas that lack the ash surface or that have gullies. Instead, dry ephemeral channels are blanketed by the ash material.

Fire and Mass Failures

Fire can have a pronounced effect on slope stability. The potential for mass movements can increase on slopes that are already prone to landslides when there is high vegetation mortality, particularly trees and shrubs. Loss of vegetation increases the amount of water in the soil. The strength that tree and shrub roots provide to a soil decreases when vegetation dies and its roots decompose.

Human Disturbances and Existing Soil Condition

Timber Harvest and Roads in the Analysis Area

Both timber harvesting and its associated road system have altered soils in the analysis area. In order to provide an indication of the extent of these activities and their effect on soils we do an analysis of the timber stand database and the roads database. This information along with literature and personnel observations of the effects of management on soils provides an indication or estimate of the amount of soil with reduced soil productivity.

The following table provides this information for the 173,347 acres soil analysis area consisting of the West Side Watersheds. This table shows the existing soil disturbances that resulted from road construction, past timber harvest since the 1950s and the disturbances associated with the West Side Fire suppression activities including the removal of hazard trees. It is important to note that there are no Forest or Regional soil quality standards for an analysis area.

Table 3-77. Existing Soil Disturbance in the Soils Analysis Area

Acres of Skid Trails and Landings that have Reduced Soil Productivity from past Timber Harvest	Acres of Land in Roads and homesites	Acres of Land Disturbed by Fire Suppression including Hazard Tree Removal	Land occupied by the Trail System	Acres/Percent of Soil Analysis Area with Detrimental Distur-bance
4257	1846	39	15	6157/3.6%

The detrimental soil disturbance caused by fire suppression during the West Side fire, by existing roads and trails system and, by the removal of the hazard trees felled during the West Side fire is based on information contained in Exhibit H-6. The landing and skid trail information is based on information in Exhibit H-7. There is no defined soil quality standard that applies to the analysis area. This exercise is done as an indicator of the current condition within the watersheds affected by the proposed activities.

Activity Areas

It is also necessary to look at the existing condition of the proposed activity areas within the project.

In conjunction with the timber stand database and aerial photographs, proposed salvage units within the West Side Fire Areas with previous management activity were individually examined on the ground in the late spring and early summer of 2004 to quantify the existing amount of detrimental soil disturbance (refer to Table 3-78).

Soil Productivity

Soil productivity is the ability of the soil to supply the water and nutrients needed to sustain plant growth. Productivity reflects soil properties such as depth, texture, and parent material. Productivity is affected by changes in organic matter, in the populations of soil microorganisms, and in physical soil properties each of which is described below:

> <u>Organic Matter</u> - Organic matter in its various forms influences soil productivity. Humus is organic matter that has been decomposed by microorganisms and whose source is not recognizable. Duff and litter are leaves, needles, and twigs that are still recognizable on the surface of soils. Large woody debris consists of woody stems greater than 3 inches in diameter (Harvey et al. 1994, page 10). Large woody debris supplies moisture to plants after the soils dry out. All organic matter provides habitat and nutrients for soil organisms.

<u>Soil Organisms</u> - Soil organisms, including fungi and bacteria, decompose 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. For example, 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, page 268).

<u>Physical Soil Properties</u> - Changes in physical soil properties occur when ground based equipment makes repeated passes over the soil (Lull 1959). These activities compact soils thus reducing pore spaces in the soil. This in turn reduces the movement of water into and through the soil and also impedes root movement through soils, reducing a plant's ability to take up water and nutrients. Compaction and other physical soil disturbances also affect soil microorganisms by altering the amount of carbon dioxide and oxygen in the soil. Changes in microorganism populations can affect soil productivity. Other physical soil disturbances include displacement and rutting. All of these physical changes are concentrated on skid trails.

These changes can be caused by management activities. Changes in soil productivity brought about by the implementation of an action alternative would be temporary. Natural processes such as freeze-thaw and root growth eventually loosen compacted soils. A literature review and assessment by Gonsior (1983, pages 13-15) mentions a maximum time for recovery of 70 years. Rutting and puddling are soil disturbances that are similar to compaction and would be expected to last a similar time. Displacement, the loss of topsoil, is a long term, and perhaps permanent loss of soil productivity. However, the management practices outlined in Chapter 2 would reduce the amount of displacement as well as reducing compaction and puddling.

Soil Erosion

Erosion is infrequent on undisturbed forest soils for two reasons: first, 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 porous and allows water to move rapidly into and through the soil profile (Goldman et al. 1986, page 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 water. As a result, water runs off (overland flow) and carries soil particles with it. Natural occurrences such as fire remove the organic matter from the soil surface. When organic matter is removed, soil pores can be plugged by fine soils moved by rainfall, resulting in overland flow and soil erosion.

Soil erosion is minimized by reducing the area where equipment operates by locating landings and skid trails on flat ground with a low or moderate erosion hazard and by using erosion control features such as water bars, vegetation, and slash placement. Management activities that leave organic matter on the soil surface also reduce soil erosion. By using these management tools in the proposed project soil erosion will be kept to a minimum.

Table 3-78. Proposed Cutting Units with Previous Timber Harvest

Units Surveyed	TYPE OF HARVEST		Date of Past Activity	Fire Area	Detrimental Disturbance
Unit No.	Proposed	Past			cat 4-6
305	Ground	Ground	1968	Ball	0%
306	Ground	Ground	1968	Ball	0%
307	Ground	No Record		Ball	
308	Ground	Ground	1984	Ball	
314	Ground	Ground		Ball	0%
315	Ground	No Record	1968	Ball	
318	Ground	No Record		Ball	0%
319s	Skyline	Skyline	1957	Ball	0%
202	Ground	No Record		Blackfoot	0%
204	Ground	No Record		Blackfoot	0%
211	Ground	Skyline	1973	Blackfoot	0%
212	Ground	Skyline	1977	Blackfoot	4%
226	Ground	Skyline		Blackfoot	0%
5	Ground	Ground	1966/1977	Beta-Doris	3%
11	Ground	Ground		Beta-Doris	0%
20	Ground	Ground	1976	Beta-Doris	0%
24	Ground	Ground	1962/1977	Beta-Doris	0%

Some units with past harvest activity have very little detrimental soil disturbance today. This could be a result of having been winter logged or a result of natural recovery of compacted and rutted and puddle soils since they were logged or the fact that the past harvest was disperse skidding that had equipment driving to a few select trees within the area. Salvage logging ranges from harvesting of extensive blowdown to removing a few dead trees. The field summary sheets from the investigation that gathered this information are in Exhibit H-3.

Mass Failure

Mass failures are not a major feature or process in the West Side drainage. The landtype mapping (soil maps) for the West Side area show two historic mass failures. They occupy about 40 acres within the Blackfoot fire area. Based on the age of the vegetation on these sites they have been stable for hundreds of years. They were probably active when the glaciers were receding, a time of widespread soil instability, or an earthquake could have triggered them. Management activities would not occur on or in proximity to these historic failures. Other small failures have been associated with roads that had improper drainage. These road associated mass failures were stabilized or rehabbed soon after they occurred.

Restoration Activities Associated with Fire Suppression and Burned Area Emergency Restoration (BAER)

Fire suppression activities such as fire lines, safety zones, and drop points have reduced soil productivity by soil compaction and soil displacement. They also have potential to increase soil erosion. However, all of the suppression activities were treated after the fire to reduce the effects on soils and other resources. These treatments included installing water bars, replacing topsoil both on hand and dozer fire lines and safety zones and seeding disturbed areas. These measures will be monitored this spring to see if they are effectively controlling soil erosion. The reduction in soil productivity on sites affected by this disturbance will last for decades and is accounted for in the existing condition for the area.

A BAER team consisting of resource specialists surveyed the West Side Fire and recommended emergency treatment to protect soils, water, and wildlife. Some of these measures were installed last fall. Culvert replacements, armoring of drive through dips, and noxious weed treatment are occurring this spring and summer. These treatments have beneficial effects on soil quality, reducing soil erosion and encouraging vegetation growth.

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:

- Total acres and percent detrimental soil disturbance in the analysis area

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.

Soil physical properties affect both the soils and soil organisms. All management activities are designed to reduce the extent and the severity of disturbances, providing conditions that allow soil organisms to survive and function and plants to take up available nutrients. In order to achieve this goal, we utilize the Regional Soil Quality Standards that specify that less than 15 percent of an activity area have detrimental soil disturbances.

The subject of allowing detrimental soil disturbance on up to 15 percent of an activity area is discussed frequently. The rational for its use is described briefly in Exhibit H-8. Until such time that ongoing research better defines acceptable limits of soil detrimental disturbance, this is a reasonable, acceptable amount. Powers and others (1990) describe the use of a 15 percent as being the lowest magnitude of change detectable given current monitoring technology. It is possible to measure the aerial extent of detrimental soil disturbance across an activity area. It is reasonable to assume that by maintaining at least 85 percent of an activity area in undisturbed or minimally disturbed, non-detrimental disturbance conditions we are maintaining soil quality. One must also consider that limiting detrimental soil disturbance to less than 15 percent of an activity area does not mean that the area disturbed is devastated. Most of the soils that are disturbed still grow native forest vegetation. These are not soils that are incapable of growing forest plants.

Direct and Indirect Effects

Alternative 1 - No Action

The No Action alternative provides a base line to evaluate the effects of the action alternatives. The effects on soils are discussed as changes over time on soil productivity, soil erosion, and mass failures.

Soil Productivity

The No Action alternative would not cause long or short-term effects on the soil resource. No road building, road decommissioning, salvage harvest, or fuels reduction would disrupt soil processes.

Organic Matter - The No Action Alternative would allow all standing dead trees to eventually fall over contributing large quantities of large woody debris. Needles and branches, especially in the areas with low fire severity (vegetation) would fall to the ground. Soil organisms would decompose the organic materials, adding humus to the soil. Nutrients associated with organic 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 again speeds up the recycling process.

In time vegetation would return to the site reducing soil erosion rates and taking up nutrients released by the fire. This process would reduce the risk of nitrogen leaching into the water table and keep the nutrients on the site and available for plant growth. Vegetation returns quickly to the low and moderate burn severity sites. High burn severity sites will re-vegetate more slowly, perhaps taking up to ten years.

Soil organisms - Soil organisms would return to the soil from adjacent or nearby unburned soils as conditions become favorable for them. Many soil organisms are transported via animals or wind. Once they are back in the soil and have organic matter as a fuel supply, the nutrient cycling processes would begin.

Physical Soil Disturbances - The No Action Alternative would cause no additional soil compaction, rutting, puddling, or soil displacement. 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 compaction would recover after 70 years without additional disturbance (Gonsior 1983 page 13-15).

Soil Erosion

The No Action Alternative would not negatively effect long-term soil erosion in the West Side Fire area. As vegetation returns the risk of soil erosion will decrease. As needles, twigs and large woody debris falls to the soil surface and creates cover, the risk of soil erosion decreases. In the short term, the No Action alternative would take longer than action alternatives to get fine and large woody debris on the ground where it would begin protecting the soil from erosion.

Mass Failures

The No Action alternative would not change the risk of mass failures.

Direct and Indirect Effects Common to all Action Alternatives

Timber Management

Soil Productivity

All action alternatives are designed to incorporate management practices that would reduce the effects from timber harvest on soil resources and insure that all activities meet the Regional Guidelines (Forest Service Manual, R-1 Supplement No. 2500-99-1, 1999). These practices are described in Chapter 2 and the BMP Appendix C.

Organic Matter - The West Side fire has changed the amount of organic material on and in the soil compared to pre-fire conditions. Forest management activities have the potential to cause additional changes, thus affecting soil productivity. To reduce the risk that salvage activities would reduce organic matter to the point of having long term effects on soils productivity, all alternatives are designed to leave a variety of the available organic matter on the site, a practice that Harvey and others (1994, page12) state can maintain soil productivity.

Large woody debris (stems greater than 3 inches in diameter) would be left on all harvested sites. All action alternatives propose to leave a variety of live and dead trees in harvest areas. This material includes all live trees where feasible, existing wildlife snags, and any live or dead hardwoods or ponderosa pine. Any trees cut as a hazard would remain on the site. These trees, both living and dead would become future large woody debris and would provide a variety of size materials for future site productivity. In addition, large woody debris would be left on the ground where it already exists. The amount left would be designed to meet the default guidelines in Amendment 21 for moist potential vegetation groups. Where the material exists, large woody debris greater than or equal to 6 feet in length would be left in these densities:

- 32 pieces average per acre 9 to 20 inches diameter and
- 15 pieces average per acre greater than or equal to 20 inches diameter.

These numbers of pieces translate to a range of 6 tons per acre if all pieces are lodgepole pine 6 feet long, to 25 tons if all pieces are western larch 20 feet long (Exhibit H-9). Graham et al. (1994, p. 11) suggest that for the habitat types present in the analysis area, between 7 and 23 tons per acres large woody debris be left on the site. In many places the amount of large woody debris left on the ground would exceed the number of pieces recommended by Amendment 21. In addition, the large amount of standing trees left in the proposed harvest areas as snags or as unmerchantable logs would provide additional future large woody debris as those trees fall over. The Deadwood Habitat Prescription Matrix (Exhibit Rd-8) describes the attrition rate for snags, which from a soils perspective translates to an addition of large woody debris over time. This Matrix and the attached description indicate that up to 30 percent of snags would fall over each year. In those areas where Western Larch (WL) and Douglas-fir (DF) exist, an average of 7 large WL or DF snags per acre would be left according to the matrix, thus each decade would see about 2 large snags per acre added to the large woody debris component. In addition, other live trees left in the units would eventually fall over adding additional future large woody debris. The end result would see large woody debris that would meet the A-21 Standards and would with time (a matter of 5 years or less) exceed the recommended amounts of Graham et al. (1994, p. 11). As a result of these inputs, soil productivity that is dependent on large woody debris would be maintained.

Table 3-79. Units with High Vegetation Burn Severity

Sale Name	Units with More than 10 % High Vegetation Burn Severity	Acres With High Severity
Ball	301H, 302H, 303H, 305, 305H, 306, 306H, 307, 307H, 308, 309H, 310H, 311H, 312H, 313H, 314, 319S, 320S, 321H, 323, 324H,	884
Beta	1H, 1R, 1S, 2R, 3H, 3R, 4R, 11H, 12, 13S, 14H, 16, 17S, 18S, 22S, 23S, 25H, 28,	794
Blackfoot	201H, 202, 202H, 202S, 203, 203H, 203S, 204, 204H, 205, 205H, 206, 206H, 207H, 208H, 209H, 210, 210H, 213H, 217H, 218H, 219H, 220H, 220S, 221H, 222H, 223, 223H, 224H, 224S, 225, 225H, 226H, 228H, 229H, 230R, 231R, 234R, 235R,	1182
Doe	101H, 104H,	90

In addition, many units would have live trees left that would eventually supply fine organic matter to the soil.

Fine organic matter in the form of small branches less than 3 inches in diameter and needles would be maintained on sites where these materials currently exist (where the fires burned vegetation with a moderate or low severity). These sites have a supply of fine organic debris that will be added to the soil surface as trees are felled during logging. The burned branches and needles are very dry and brittle and would break off of the trees that are cut down. In the areas where vegetation was burned at high severity level fine organic material is in short supply because it has burned off during the fires. This would be the case with or without logging. The lack of fine material could reduce the amount of nutrients available for forest vegetation, but this situation also occurs after fires that are not salvaged. The following units were burned with high burn severity (vegetation) and have low amounts of fine organic matter now and will have about the same amount after salvage logging:

Site Preparation - Helicopter units would have the limbs and tops cut from trees before they are removed from the cutting area. Within skyline units and ground based units the limbs and tops would most likely be removed with the trees. However, because the limbs and needles are burned, dead and brittle, many would break off and remain behind in the cutting units.

If mechanical fuel treatments were deemed necessary after the fire they would be accomplished with excavators that operate on existing skid trails to reduce soil disturbance. This practice was monitored on the Flathead National Forest and found to meet the soil quality standards (Land and Resource Management Plan Annual Monitoring Report, 1992 page 131-139). Another option would be to jackpot burn where debris is accumulated in amounts that are deemed a hazard. This situation would generally coincide with areas of low burn severity and thus would be unlikely to cause additional soil detrimental disturbance

After project implementation all units are expected to have quantities of fine organic matter similar to the existing post fire conditions. Units within high fire severity (vegetation) may lack fine organic materials to provide nutrients, but would have no less than what is present now. These post-harvest conditions would maintain soil productivity at levels within the normal range of variation for sites burned by wildfire.

Soil Organisms- The West Side Fire has changed the microorganism populations. Jurgenson et al. (1977, page 248) note that after a fire, soil micro-flora recovers quite rapidly, frequently to levels greater than the original. Borchers and Perry (1990, pages 149 and 151) discussed the important role that less disturbed areas of soil play in inoculating soil that lacks or has reduced numbers of soil organisms. They state that unburned areas within burns, adjacent unburned areas, unburned large woody debris, and soils that have only minor amounts of disturbance contain propagules for fungi, bacteria and other soil organisms. Agents such as wind and animals disperse the propagules across the burned landscape.

The harvest activities in the West Side area are designed to salvage trees in a way that provides the habitat required by soil organisms and thus would maintain soil nutrient cycling processes. The fine and large organic matter left on the harvest areas would benefit soil organisms by providing substrate for them to decompose, and habitat for them to survive in. Soil organisms would return to the sites within a few years as vegetation returns to the site. These processes would work to maintain the productivity of the salvage sites at a level consistent with burn areas that are not salvaged. The sites that burned with a high severity on vegetation will be lacking in fine organic matter and may experience a slow return of soil organisms causing a temporary reduction in nutrient cycling and thus a reduction of nutrients available for vegetation. However, as vegetation returns and soil conditions improve, the organisms will return from adjacent soils.

Soil compaction, puddling, rutting, and displacement change a soils ability to exchange oxygen and carbon dioxide. This condition affects the ability of soil organisms to survive. However, all proposed harvest areas would be designed to reduce soil disturbance and meet the Regional soil guidelines of less than 15 percent of an activity area having detrimental soil disturbances. Thus at least 85 percent of the soils within activity areas would provide favorable habitat for soil organisms.

Timber harvest exposes soils to sunlight, increasing both soil temperatures and the amount of available soil moisture. Warm, moist conditions increase microbial activity and thus increase the rate of decomposition of organic matter on a site. In turn, nutrients are made available for plants (Harvey et al. 1994, page11). Currently, many areas within the burn have vegetation, an indication that soil processes are already functioning at levels expected after a fire. At least 85 percent of the harvested soil would be protected from detrimental soil disturbances. This design feature would maintain the ability of soil organisms to survive and carry on soil processes throughout the areas salvaged.

The design features would ensure that a variety of organic matter is left on the site and would also minimize soil detrimental disturbance. As a result of these practices, soil organisms will have a favorable environment for survival in the West Side areas planned for salvage. No long lasting changes in long-term soil productivity caused by a lack of soil organisms would occur as a result of the proposed activities. Areas of high burn severity (vegetation) would lack fine organic matter and thus soil processes would be slowed and fewer nutrients would be available for plant use. However, this condition already exists as a result of the fire.

Physical Soil Properties

Harvesting of all proposed cutting units is designed to insure detrimental soil effects are below 15 percent of the activity area. This would be achieved by implementing the design features described in Chapter 2 and the BMPs described in Appendix C.

Helicopter yarding

All helicopter units would meet the Regional Soil Guidelines. McIver and Starr (2000, p. 14-16 and p. 45-46) reviewed the literature on the amount of soil disturbance from various logging systems. The literature they looked at stated that helicopter yarding caused less than 1 percent severe soil disturbance in the areas harvested. Helicopter yarding avoids the impacts from ground-based equipment within a cutting unit. Three units were monitored for detrimental soil disturbance following helicopter logging on the Moose Fire Salvage project. All of the units had been previously logged to varying degrees. After helicopter yarding, all of the units met the regional soil guidelines and none added more than 1 percent detrimental soil disturbance to the pre salvage conditions (Exhibit H-10).

Landings are the major source of disturbance from helicopter yarding. Approximately 65 acres of soil would be disturbed for use as helicopter log landings with Alternatives B, D, and E. About 59 acres would be disturbed for Alternative C. Landings would be located on suitable lands away from streams. When helicopter landings are no longer needed they would be seeded with an appropriate seed mix of short lived non native plants or with a mix of native plants. Where needed, based on monitoring, the landings would be reshaped or lightly ripped to increase infiltration and reduce erosion.

If ground based equipment were used to log the helicopter acres in alternative B (3498 acres) it would cause up to 525 acres of detrimental soil disturbance. The landings for the same acres of helicopter harvest will occupy about 65 acres or approximately 2 percent of the helicopter logged acres, with a possibility of up to 35 additional acres caused by the helicopter yarding.

Skyline yarding

Skyline yarding disturbs only the corridor where the logs are pulled up hill. McIver and Starr (2000, p. 14-16 and p. 45-46) reviewed literature and found skyline yarding disturbed 2.8 percent of the soil in a unit. Monitoring of skyline yarding on similar soils on the Flathead National Forest found 6 to 9 percent detrimental soil disturbance on units that had the trees cut with a ground based equipment and skyline yarded up hill or that were skyline yarded and had an excavator pile slash (Exhibit H-11). The unit with 9 percent detrimental disturbance included disturbance from an old historic road at the bottom of the unit that was not used for the activity that was monitored. Skyline yarding will meet the Region 1 Soil Quality Standards.

Ground based yarding

Ground based equipment compacts or displaces the soil where it operates. Most of this disturbance occurs on skid trails and landings. The amount of detrimental soil disturbance depends on the number of trips the equipment makes and the ground conditions at the time it operates. The higher the soil burn severity the more susceptible an area is to the effects of ground-based equipment. In order to protect the soil from detrimental soil disturbance during ground based equipment operation, skidding would occur in winter when there is snow on the ground or when soils are frozen. Several units within the Moose Fire Salvage project that were yarded with ground based equipment were monitored in 2003; all of them met the soil quality guides (Exhibit H-12. Several harvest areas were winter logged as part of the Sula State Forest Fire Mitigation Salvage Harvest project. The monitoring report for that project shows reduced soil detrimental conditions for winter logging compared to summer logging (Montana Department of Natural Resources, pp 12-14. 2002). A study in Oregon (Williams and Buckhouse, 1993, p. 22) identified no runoff or sediment production following winter logging and attributed it to the lack of disturbance caused by winter logging.

A way to display the potential for detrimental soil disturbance from the proposed salvage logging is the acres of yarding systems proposed for each alternative. Helicopter, skyline yarding, and winter yarding with ground based equipment all cause less detrimental soil disturbance that the Regional Soil Standards allow. Ground yarding in summer also meets the standards, but is usually close to the limit, thus it has a higher risk of exceeding the standards if operations go wrong than do the other yarding methods. However, because of the slopes and the burned conditions all ground based yarding is proposed for winter operations. Table 3-80 displays the acres of each of these harvest methods.

Table 3-80. Acres of Proposed Harvest Method by Alternative

Alternative	Acres of Helicopter Yarding	Acres of Skyline Yarding	Acres of Ground Based Yarding in Winter	Total Acres Proposed for Logging
A	0	0	0	0
B	3498	785	623	4906
C	2844	690	367	3901
D	3762	875	663	5300
E	3804	871	630	5305

Changes in soil productivity brought about by the implementation of an action alternative would be temporary. Natural processes such as freeze-thaw, root growth and the activity of soil organisms eventually loosen compacted soils. A literature review and assessment by Gonsior (1983, pages 13-15) mentions a maximum time for recovery for soil compaction of 70 years. Rutting and puddling are soil disturbances that are similar to compaction and would last a similar time. Displacement, which is the loss of topsoil, is a long term, and perhaps permanent loss of soil productivity. The design features described in chapter 2 would reduce the amount of displacement, compaction, rutting and puddling to amounts that are within the Region 1 guidelines.

Detrimental soil disturbance occurs in varying degrees. Some soils that have detrimental disturbance are still capable of growing native vegetation. Soils with light detrimental disturbance would still grow vegetation and would be difficult to differentiate from undisturbed soils in a short time. The heaviest detrimental soil disturbance has bare soils that will be slow to vegetate and are susceptible to erosion and invasion of non-native plants. These soils can take decades to recover.

Soil disturbance from felling trees would be negligible. Trees that blow over and tear their roots out of the soil disturb more soil than trees that are cut down. In addition, trees that are cut leave their roots in the soil where they eventually break down and become important soil wood for soil organisms.

Fuels reduction or site preparation work, where needed, would be accomplished with excavators that operate on skid trails and do not cause additional soil disturbance. The harvest activities are designed to minimize the amount of soil disturbance off skid trails. Where skid trails already exist from previous activities, they would be reused to the extent feasible, reducing the amount of additional detrimental soil disturbance.

These practices would maintain soil productivity at levels that would meet the Regional soil quality standards.

Soil Erosion

Forests generally have low erosion rates unless a disturbance exposes bare soils. The risk of erosion increases as slope increases, as soil cover decreases and as the lineal length of disturbance increases. The same practices that maintain soil productivity, such as leaving organic material on the soil surface and reducing the area impacted by skid trails also reduce soil disturbance and the risk of soil erosion. In addition, implementing erosion control measures that are described in the design features in Chapter 2 will also reduce the risk of soil erosion from those soils that are disturbed.

The WEPP (Water Erosion Prediction Project) model was used to estimate the change in erosion rates after the project is completed and the erosion control practices described in Chapter 2 are implemented. The results (Exhibit N-13) indicate that the slash left on the ground after logging in helicopter units would reduce soil erosion by 82 percent from post fire conditions over 5 years. Installing waterbars and placing slash on skid trails created by ground skidding would reduce soil erosion by 88 percent. Erosion on skyline-yarded units would be reduced by 91 percent in cable corridors by the same practices. The WEPP model as it was used for this analysis does not route or indicate the fate of eroded soil.

The proposed harvest treatments have the potential to decrease soil erosion compared to the current erosion rates on burned soils. This would occur because harvest would hasten the rate at which debris and litter cover the burned soils, reducing the amount of soil moved by sheet erosion.

The length of time erosion continues depends on how soon soils vegetate or become armored with rock or have soil erosion control features implemented. In the West Side project, erosion control measures would be implemented immediately as needed.

Mass Failure

The shear strength of roots provides important structural reinforcement and buttressing on slopes. Live roots increase the stability of soils on steep slopes by binding the soil to the underlying fractured bedrock or by adding shear strength to deep glacial soils. When live trees are harvested these attributes change and the risk of mass failure increases. However, the dead roots remaining after the fire-killed trees are harvested will bind the soils to the underlying bedrock the same as if the trees had not been salvaged. Planting trees and shrubs, as happening as part of the post fire restoration will gradually stabilize soils. All action alternatives include reforestation, which would further stabilize soils. Critical mass failure prone areas are not in this proposal.

Road Management

Soil Productivity

Roads change physical soil properties. No new permanent roads would be constructed for this project, thus would cause no additional detrimental soil disturbance.

Some proposed road management would have a long-term benefit to soil productivity. All action alternatives would decommission roads, ranging in amount from 49 miles (147 acres of soil disturbance) for alternatives B and E to 69 miles (207 miles of soil disturbance) for alternatives C and D. Soil productivity would slowly increase on the decommissioned roads. The elimination of traffic would favor increased growth of vegetation, which would in turn increase the amount of organic matter in the soil and gradually loosen compacted soils. This process could take 100s of years to restore productivity levels to what they were previous to road construction.

Roads that remain on the forest road system but are closed to use with a gate would also see slowly improving soil productivity, but occasional traffic would limit the amount of recovery.

Some roads would be closed with a berm, eliminating traffic. These roads would also see slowly recovering soil productivity. However, the recovery could be set back if the roads were used at some time in the future.

Table 3-81. Acres improved or disturbed by road management.

Alternative	Decommissioned Roads (miles/acres)	Roads closed with a berm (miles/acres)	Roads closed with a gate (miles/acres)	Acres of Soil Improved (+) or Detrimentally Disturbed (-)
A	0/0	49/147	106/318	+147
B	49/147	85/255	48/144	+402
C	69/207	78/234	54/162	+441
D	69/207	82/246	60/180	+453
E	49/147	85/255	46/138	+402

Temporary roads would be constructed with all alternatives. All temporary roads would be reclaimed and vegetated. Slash, where available would be placed on the road, and erosion control features would be added. All alternatives would build the same amount of roads, 4 miles, equal to about 12 acres of disturbed soils. All of the temporary roads would be on existing historic road templates. These roads have been bermed and inaccessible to vehicles, thus the soils in the roads have been slowly recovering from compaction, displacement rutting and puddling. Using the historic roads for temporary roads would set back any recovery of soil health that has occurred on 12 acres. However, after the temporary roads are reclaimed, soil quality would slowly increase again taking 100s of years. This is a long but temporary set back from the existing condition.

Soil Erosion

Erosion from open roads does not have an effect on soil productivity because the roads are dedicated to the transportation system and are not expected to produce vegetation. Erosion from decommissioned roads or bermed roads does reduce soil productivity because those roads are slowly improving in soil quality. Road decommissioning would cause a short-term increase in soil erosion. Disturbed soils would be at risk of eroding until erosion control features are installed and vegetation returns. However, decommissioning would minimize both the time and extent of bare soils and thus would minimize the amount of soil erosion. In the long term there would be a net decrease in soil erosion potential. Roads that remain on the forest road system but are closed with a berm would also have less soil erosion in the future as vegetation returns to the site.

Mass Failure

New permanent roads would not be built with any alternative, thus the risk that a new road would cause mass failures is eliminated. When a road is decommissioned all culverts at stream crossings are removed and additional drainage is added to the remaining road template. Therefore, roads that are decommissioned would have a reduced risk of road-associated mass failures.

Alternative C

Salvage Harvest

Alternative C would not salvage in areas that were identified as being more sensitive to harvest operations and burned tree removal. Sensitivity is based on several resource concerns including soil, wildlife, old growth, and others. Only the units that would be dropped for soils issues are discussed here. These include two units in Goldie Creek that were severely burned and would benefit from having no additional soil disturbance (Units 208H and 210H). Other units were removed because they meet the criteria for “sensitive soils” as defined in the soils section (page 2 SOILS SECTION). The units are 315, 323, 220S, and 211. Eliminating these units eliminates the risk of causing detrimental soil disturbance on units that are severely burned or are wet.

This alternative would also reduce the risk that the soil quality guides would be exceeded.

Alternative D

Alternative D would retain fewer snags than the proposed action. The effect on soil conditions would be to have less large woody debris on the site in the future. The guides for large woody debris would still be met at both the completion of this project and in the future.

The effect on long term productivity would be a minimal reduction in habitat for soil organisms compared to the results of the other alternatives. Alternative D could result in a slower recovery to levels of large woody debris and soil organisms that are comparable to those existing prior to the fire than the other alternatives, resulting in a small short term decrease in soil productivity in the future compared to the other alternatives.

Alternative D would utilize trap trees to control bark beetles would be used with this alternative. This activity involves falling trees, allowing the insects to bore into the trees and then removing the trees. This would occur with a relatively small number of trees and would cause a small amount of additional soil compaction, displacement, puddling, or rutting associated with this activity. In addition, the amount of organic debris would be unaffected because the limbs would be cut and left on the site. The net effect on soil productivity would be difficult to measure.

Cumulative Effects

Past Actions

This section lists the past activities that have occurred in the West Side area. Following each activity is a simple statement on if they were used for the cumulative effect analysis and if not why.

- Timber Harvest – Acres of timber harvest are part of the cumulative effects.

- Road Construction – Acres of land used for roads is part of the cumulative effects.
- Trail Construction—Acres of land used for trails is part of the cumulative effects.
- Precommercial Thinning – Precommercial thinning uses hand tools and all trees cut remain on the site. It was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- Fish Stocking – It was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- Wildland Fire – is a natural process and is not included in this cumulative effects analysis, with the exception of the fires that burned in the West Side analysis area in 2003.
- Predator Control –was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- Beaver Control –was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- Construction of Hungry Horse Dam – removed land from the production of forest vegetation, but is considered as a dedicated land use and was not part of the cumulative effects analysis.

Present Actions

Present actions in the soil analysis area include the following:

- Wildland Fire Suppression –wildland fires have been actively suppressed by the Forest Service and will continue. These activities cause some detrimental soil disturbance, which is part of the cumulative effects analysis.
- Noxious Weed Treatment –Weed treatments will continue. As a result of weed treatment soils have a stand of more desirable plants that are better suited to building organic reserves and preventing erosion than are noxious weeds. All label requirements are followed. This activity has minimal beneficial effects on soils and is not included in the cumulative effects analysis.
- Hunting, Fishing, Trapping –was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- Firewood and Other Miscellaneous Forest Product Gathering – Other products include posts and poles, mushrooms, Pacific yew boughs and Christmas trees. These activities remove some potential organic matter from the soils and result in a small amount of trampling about by people. It was not used in the cumulative effects analysis because it has an immeasurable effect on soil quality.
- Snowmobiling –Small areas of soil are occasionally disturbed if snowmobiles operate when snow is shallow. It was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- Camping/Boating –. It was not used in the cumulative effects analysis because it has no effect on soil quality.
- Driving, Motorized Trail Riding, Mountain Biking and Hiking –These activities occur on existing roads and trails that are part of the soil detrimental disturbances accounted for in Tables 3-77 and 3-82

- Road Maintenance and Trail Maintenance – Reduces soil erosion from the road or trail but has no direct effect on soil quality. The area covered by roads and trails are part of the cumulative effects analysis for soils.
- Heinrude Home Sites – An area of National Forest System (NFS) land adjacent to Hungry Horse Reservoir and near Quintonkon Creek is designated for private home sites. Nineteen home sites of approximately one-half acre each occupy the area. The acres covered by homesites are accounted for in Tables 3-77 and 3-82.

Foreseeable Actions

- Temporary Road Openings - It was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- Larch Heart Rot Research –It was not used in the cumulative effects analysis because it has no measurable effect on soil quality.
- High Mountain Lakes Fisheries Management – It was not used in the cumulative effects analysis because it has no measurable effect on soil quality.

Soil Analysis Area (173,347 acres)

The cumulative effects analysis for the West Side area includes both existing soil disturbances from past activities and the expected disturbances from the proposed activities. This analysis is a modeling exercise that makes use of data from the timber stand database, road location GIS data, and the results of past monitoring, literature searches, and discussions with other soils personnel in the Forest Service. Table 3-81 displays the estimated total acres of detrimental soil disturbances. There are no Regional or Forest standards/guidelines for the amount of area impacted within an analysis area. This information is provided to indicate the overall watershed condition and to provide a comparison of the effects by alternative. For comparison, in the Spotted Kah, Island Unit, and Good Creek analysis areas the total existing disturbance has ranged from 3 to 14 percent.

On an analysis area basis, none of the alternatives are better than the other in reducing soil impacts. However, Alternative C would potentially reduce soil impacts within the analysis area because it harvests fewer acres and eliminates selected units that are situated on the most sensitive soils. Thus it reduces the risk that excessive soil detrimental disturbances would occur.

Activity Areas (cutting units)

Cumulative effects were assessed within each activity area. These effects include past, present, and proposed impacts to soil productivity. All units with previous management activity listed in Table 3-78 were reviewed on the ground to quantify the effects from past timber harvest and determine if existing levels of detrimental soil disturbance exceed the Regional soil quality guides.

Table 3-82. Effects of Past, Present and Proposed Treatments on Soil Analysis Area by Alternative

Alternative	Existing disturbance (roads, trails and timber harvest, including hazard tree removal) in acres	Proposed Disturbance from Forest Management Including Temporary Roads (acres) Skid trails and Landings and Fuels Reduction Treatments	Changes from Road Decommissioning in Acres[1] (These acres will cause improved soil productivity and reduced erosion over time) [2]	Total acres Disturbance / % of Analysis Area (173,347 acres in soil analysis area)
A	6157	0	0	6157/3.6
B	6157	167	-147	6177/3.6
C	6157	119	-207	6069/3.5
D	6157	181	-207	6131/3.5
E	6157	177	-147	6187/3.6

1 The column 'Changes from Road Decommissioning' includes decommissioning occurring from previous decisions that would still occur under the no action alternative.
2 The improvements in soil quality from roads that are closed with a berm or a gate can be negated if those roads are used in the future. Therefore, they are not included in this table.

Monitoring of the units with previous activity would occur again following project implementation. The guidance in Forest Service Manual Supplement No. 2500-99-1 (USDA Forest Service 1999) would be followed. It states that where an activity area such as a cutting unit has had previous management that caused less than 15 percent detrimental soils conditions, the cumulative detrimental effect of the proposed activity following project implementation and restoration must not exceed 15 percent detrimental soil conditions. It further states that where more than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and restoration should not exceed the conditions prior to the proposed project and should move towards a net improvement in soil quality. This direction would be followed for the proposed second entries within the West Side area. Restoration activities such as reclaiming landings and skid trails would be the primary means to restore soil quality.

Risk of Exceeding Soil Quality Guidelines

In units that were not previously managed, helicopter, skyline yarding and ground based yarding in winter will not cause detrimental soil disturbance that exceeds the Region 1 guidelines. Helicopter yarding would disturb one percent or less of the soil surface (McIver and Starr 2000, pages 14-16 and pages 45-46). During monitoring of helicopter logging on the Flathead National Forest it is difficult to see or measure soil disturbance (personal observation, Bill Basko). Monitoring of the Happy Trails timber sale showed no measurable or observable soil disturbance caused by helicopter logging (Exhibit N-14). Skyline yarding is proposed only for units that were previously skyline yarded. Purser and Cundy (1992), found skyline yarding disturbed about 5 percent of a cutting unit.

Ground based yarding of units that were not previously managed is expected to meet the Regional Guidelines if it is done according to the management practices listed in Chapter 2. The skid trails and landings would be designed to occupy less than 15 percent of the area. If they need to be closer together, they would then be protected by a slash mat, which monitoring has shown to be effective at protecting soil from compaction, rutting, puddling, and displacement (Soil Monitoring Report, Help Creek Timber Sale, 1999). The requirements for a slash mat are described in Chapter 2. Winter logging over snow or frozen ground is another option available to protect soils during ground based yarding of trees. Several monitoring reports show winter operations greatly reduce the effect on soils (Montana Department of Natural Resources, 2002 pages 12-15 and Land and Resource Management Plan Annual Monitoring Report, 1992 pages 131-139).

Ground based yarding of units that were previously managed have a higher risk of exceeding Regional guidelines than do helicopter, skyline yarding, or ground based yarding on units that were not previously managed. Units that would be managed a second time are listed in Table 3-78. Units with proposed ground based yarding and previous management will be monitored after salvage harvest. If detrimental soil disturbance exceeds 15 percent, we will implement restoration measures. However, all management practices are designed to meet the Region 1 Soil Quality Standards of less than 15 percent of an activity area with detrimental soil disturbance. Restoration of soils is not part of alternative design and would be used only if monitoring after project implementation shows that the soil quality standards were exceeded.

Risk of Exceeding Soil Quality Guidelines with a Second Entry

There is little risk that the soil quality guides would be exceeded as a result of a second entry in the Proposed units of the Westside project. All units with past activity had less than 4 percent detrimental soil disturbance (Table 3-78). Units 5 and 212 had disturbance from past management amounting to 4 percent or less of the unit area. Both units 5 and 212 would be winter logged, an activity with known ability to reduce impacts to soils as discussed earlier.

Skyline yarding has the lowest risk of causing cumulative soil effects that exceed the soil quality guidelines because all units proposed for skyline logging were skyline yarded in their previous management activities. It is likely that many existing skyline corridors would be reused. However, even if all new corridors were used, the total detrimental soil disturbance would be about 10 percent, which is within the Regional Guidelines.

Units that are proposed for helicopter yarding have a low risk of causing cumulative soil effects that exceed the soil quality guidelines, because helicopter yarding disturbs one percent or less of the activity area.

Yarding with ground-based equipment has the highest risk of causing cumulative effects that exceed the soil quality guidelines. The effective implementation of the mitigations and management practices built into the activities is crucial. Many of these units would be monitored after project completion. If the guidelines are exceeded, heavily used landings and skid trails would be restored with the goal of either reducing impacts to less than 15 percent of the area or to less than existed before salvage harvest was implemented.

Restoration Effectiveness

If needed, restoration activities to improve soil conditions would include ripping heavily used skid trails and landings that are compacted. The goal would be to reduce soil compaction and meet the direction provided in Region 1 Supplement 2500-99-1 (See Regulatory Framework at end of this section). Several studies discuss the effectiveness of ripping as a soil restoration activity. Studies cited by Froehlich and McNabb (1983, p. 22-23) 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 the British Columbia Ministry of Forests (Bulmer 1998 p. 10) cites a study 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 subsoiling 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. 13) and improve the environment for soil organisms.

REGULATORY FRAMEWORK AND CONSISTENCY

Region 1 Soil Quality Standards - All proposed activities are designed to meet the Region 1 Soil Quality Standards. These standards require that soil properties and site characteristics be managed in a manner consistent with the maintenance of long-term soil productivity, soil hydrologic function, and ecosystem health.

Region 1 Supplement 2500-99-1 (USDA Forest Service 1999) 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 timber sale. It also states that in areas where less than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects of the current activity following project implementation and any needed restoration activities must not exceed 15 percent. In areas where more than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and needed restoration activities should not exceed the conditions prior to the planned activity and should move toward a net improvement in soils quality.

Forest Plan Management Direction - Forest wide standards for soil resources in the Forest Plan, page II-46, are:
1) "Ensure that all resource management activities will maintain soil productivity and minimize erosion through implementation of:
a) Management direction presented in the Landtype Guidelines (Appendix Q); and
b) Erosion Prevention Standards (Engineering Handbook Supplement).
2) "Design or modify all management practices as necessary to protect land productivity".

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.