V. SOILS

1. Analysis Area and Analysis Methods

The analysis area for soils encompasses all lands within the boundaries of the Big Creek watershed (52,524 acres). This analysis area was selected because all proposed management activities would occur within the watershed. A landtype map for the area is located in the project record as project record N-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 found in the project record as project record N-3. 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. Management practices and mitigation measures will be designed to protect sensitive soils based on the slope of the ground and the burn severity. A map of burn severity ratings and unit location is located in the project record (project record N-5).

The effects analysis follows the process described in the Soil Analysis Guideline contained in project record N-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 significant change in soil quality (Forest Service Manual, R-1 Supplement No. 2500-99-1, 1999).

2. Affected Environment

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.

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 Moose 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 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 Moose Fire (refer to Map 3-10 and Table 3-53). Burn severity describes the fire-caused damage to the soil, and varies from that described vegetation. 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. A map of the burn severity for the fire is found in the project record as project record N-5. Burn severity is discussed in depth in the Soils Report for the Burned Area Emergency Rehabilitation (BAER) project (project record N-6).

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 re-vegetation 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 rain-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 many of the high and moderate burn severity sites on non-volcanic ash soils project recorded water repellency. A discussion of hydrophobic soils is in the soils report portion of the BAER Report for the fire (project record N-6). Literature on hydrophobic soils indicates that this condition should naturally decline as fall rains and melting snow wet the soil profile (DeByle 1973 page 86). Observations in the fire area on April 16, 2002 were that soils were wet throughout their depth, indicating they were no longer hydrophobic (project record N-14).

Table 3-53: Burn severity acreage for the Moose Fire

Burn Severity	Acres	Percent
High	856	1
Moderate	25,037	38
Low	4,672	7
Low/Unburned Mosaic	32,535	50
Unburned	2,294	4
Total	65,495	100

Note- Acreages in the table reflect the Sept. 17 burn severity map including Glacier National Park.

MAP 3-10 : Burn severity affects on soil

See adjacent color insert.

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 and others, 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 Big Creek ecosystem since the glaciers retreated some 10,000 years ago. Numerous wildfires have run their course in the Big Creek 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 Big Creek area shows little evidence that extensive erosion has occurred since the deposition of the volcanic ash layer 6,600 years ago from the eruption of Mt. Mazama in southwest Oregon. If numerous significant erosion events had occurred one would 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.

One new slump was noted on April 16, 2002. It was a small slump associated with a road cut slope on the North Fork road. The total amount of material moved was about 10 cubic yards (equal to one large dump truck load).

On June 3, 2002, two small cut slope slumps were noted associated with Road #2656 in Lookout Creek. The total amount of material moved was approximately 18 cubic yards.

In addition, the pre-existing large natural mass failure directly west of the Big Creek Education Center has become active since the fire burned the vegetation cover on the landslide. There is surface raveling of the soils from this landslide down into Big Creek. This may account for approximately 30 to 40 cubic yards of eroded soil materials.

Relatively, the amount of mass failure occurring in the Big Creek Area is minimal as compared to other landscapes that are more sensitive to post-fire mass failure. This amount of small road-associated mass failure is not unusual during a wet spring in Big Creek.

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 52,524 acres soil analysis area consisting of the Big Creek watershed. This table shows the existing soil disturbances that resulted from road construction, past timber harvest since the 1950s and the disturbances associated with the Moose 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 3-54: 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	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 Disturbance
3579	594	157	15	4345/8.3%

The detrimental soil disturbance caused by fire suppression during the Moose fire, by existing trails system and, by the removal of the hazard trees felled during the Moose fire is based on information contained in project record N-20. The landing and skid trail information is based on information in project record N-17.

Activity Areas

It is also necessary to look at the existing condition of the proposed activity areas within the project. The Region 1 Supplement 2500-99-1 (project record N-8) 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.

In conjunction with the timber stand database (N-9) and aerial photographs, proposed salvage units with previous management activity were individually examined on the ground to quantify the existing amount of detrimental soil disturbance. Soil disturbance assessment forms are available in the project record (N-21) for each of the units listed in Table 3-52.

Many proposed units have had no past management activities. Their existing condition is best defined using the burn severity mapping, landtype information and the Appendix A – Group Treatments for the Moose project. A table located in the project record as project record N-10 lists the burn severity for each proposed unit. This information along with the slope of each proposed unit are the basis for applying management practices that maintain soil productivity and control soil erosion. Those management practices are described in Chapter 2, in the section called Design Criteria Common to All Alternatives.

If a unit meets the current guidelines, there is less than 15 percent of the proposed salvage unit with detrimental soil disturbance. Units with 15 percent or more detrimental disturbance exceed the guidelines.

Table 3-55: Proposed Cutting Units with Previous Timber Harvest

Unit Number	Acres in Proposed Units	Previous Activity/Acres of Previous Activity	Date of Previous Activity	Current Compliance with Guidelines
3	208	Salvage/60	1971-1989	Meets
7	136	Salvage/11	1971	Meets
8	115	Salvage/76	1971-1984	Meets
9	40	Salvage/9	1971	Meets
10	27	OSR/14	1975	Meets
12	6	CC/3	1969	Meets
13	8	SW, CT/5	1972	Exceeds
14	73	Salvage, SW/5	1974	Meets
16	107	Salvage/12	1983,1988	Meets
19	48	Salvage, ST/34	1966-1983	Exceeds
20	33	Salvage/28	1983,1988	Meets
21	35	Salvage/9	1983	Meets
23	35	SW/35	1974-1985	Exceeds
24	11	SW/11	1981	Exceeds
25	29	SW/29	1962,1981	Meets
26	32	Salvage, SW/16	1961,1988	Exceeds
27	27	Various/30	1961,1982	Meets
28	33	Salvage, ST/6	1982,1983	Meets
29	12	SW/3	1962,1981	Meets
30	11	GroupSelect/9	1993	Meets
33	11	OSR/3	1974	Meets
35	19	Salvage/3	1983	Meets
38	104	SWR/100	1981	Meets
41	50	Salvage/30	1980	Exceeds
42	40	Salvage/14	1980	Meets
43	21	Salvage/6	1983	Meets
44	42	Salvage/7	1982	Meets
45	17	Salvage/3	1975	Meets
46	24	Salvage/24	1975	Meets
47	65	SW/57	1975	Meets
49	17	SW/13	1974	Meets
50	30	SW/28	1974,1982	Meets
58	72	ST, SW/50	1976-1993	Meets
59	69	ST, SW/67	1974-1993	Meets
60	30	SW/30	1993	Meets
61	71	SW, Salvage/3	1975,1984	Meets
63	122	SW, Salvage/100	1976,1988	Meets
64	9	Salvage/7	1983	Meets
65	117	Salvage/70	1983	Meets
66	85	ST, Salvage/70	1983	Meets

ST = Seed tree harvest, SW = Shelterwood harvest, OSR = Overstory removal, CC = Clear cut, CT = Commercial thin.

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. 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.

Organic Matter - 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.

Soil Organisms - 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).

Physical Soil Properties - Changes in physical soil properties occur when ground based equipment makes repeated passes over the soil (Lull 1959). These activities compact soils, reducing the amount of 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.

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.

Mass Failure

Mass failures are not a major feature or process in the Big Creek drainage. Two historic mass failures are mapped in the Big Creek drainage (project record N-1). 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. A large failure and a few smaller ones are along the lower reaches of Big Creek. They appear to be a result of undercutting by Big Creek. Management activities are not proposed in proximity to these failures. Other small failures have been associated with roads that had improper drainage. Most of these road associated mass failures were stabilized/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.

A BAER team consisting of resource specialists surveyed the Moose Fire and recommended emergency treatment to protect soils, water and wildlife. Some of these measures were installed last fall (detailed in Hydrology Section). Culvert replacements, armoring of drive through dips, the reclaiming of road 316E and 5286 and noxious weed treatment will be implemented as soon as possible this spring and summer. Among the goals of these treatments is to protect the soil from erosion. They have beneficial effects on soil quality, reducing soil erosion and encouraging vegetation growth.

3. 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.

Direct and Indirect Effects of 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 short-term effects on the soil resource over and above the existing condition. No additional road building, road decommissioning, salvage harvest or fuels reduction would disrupt the natural soil processes.

Organic Matter - The No Action Alternative would allow all standing dead trees to eventually fall over contributing large quantities of coarse woody debris. Needles and branches, especially in the areas with low fire severity would fall to the ground. Soil organisms would decompose the organic materials, 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.

Vegetation would return to the site. It would reduce soil erosion rates and capture some of the nutrients released by the fire. This process would reduce the risk of nitrogen leaching into the water table. Vegetation is present and will reestablish quickly on the low burn severity soils. Moderate and high burn severity will re-vegetate more slowly, perhaps taking more than ten years.

Microorganisms - Microorganisms would return to the soil from adjacent or nearby unburned soils as conditions become favorable for them. Once they are back in the soil the nutrient cycling processes would begin again.

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 Moose Fire area. As vegetation returns the risk of soil erosion will decrease. Needles, twigs and large woody debris falling to the soil surface would further reduce the risk of soil erosion on low and moderate burn severity sites. 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. This statement is based on the WEPP (water erosion prediction project) model runs made to determine the effects of harvest on soil erosion (see project record N-12).

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 occurring where previous management has not occurred meet the Regional Guidelines (see project record N-8). These practices are described in Chapter 2 and the BMP Appendix C.

Organic Matter - The Moose fire has greatly changed the amount of organic material on and in the soil. Forest management activities have the potential to further change the amount of organic matter on the ground, thus affecting soil productivity. However, all alternatives are designed to leave a variety of organic matter on the site, a

practice that Harvey and others (1994, page12) say maintains productivity. The snag and coarse woody debris prescriptions for each unit are in Appendix A.

Both coarse woody debris (stems greater than 3 inches in diameter) and fine organic matter would be left on the harvested sites. Snags, live trees, larch greater than 18 inches in diameter, and non-merchantable trees would be left in the units. This material would become coarse woody debris in the future. The details of the snag and coarse woody debris prescriptions are in Appendix A. Fine organic material would result from harvest. Most proposed harvest units that are in low or moderate burn severity have enough fine material to supply the needs for productivity. High burn severity sites may lack fine organic material. However, salvage harvest on these high burn severity sites would not decrease the amount of existing fine organic material available in these areas.

Post harvest fuel treatment is not planned unless a unit has in excess of 30 tons per acre of fuels including both fine and coarse material. Fuels in excess of 30 tons per acre would not automatically initiate fuels reduction treatments. If a unit has more than 30 tons per acre, consideration of factors such as unit location, surrounding fuel conditions, continuity and size of the slash would be used to determine whether fuel reduction would occur.

If mechanical fuel treatments were deemed necessary they would be accomplished with excavators to reduce soil disturbance (Land and Resource Management Plan Annual Monitoring Report, 1992 page 131-139).

Based on these management practices for coarse woody debris, snags and fuels reduction, all units are expected to have adequate quantities of fine and coarse organic materials to provide nutrients, habitat for soil microorganisms and substrate for nutrient cycling. These post-harvest conditions would maintain soil productivity.

Microorganisms - The Moose Fire has greatly changed the microorganism populations. Jurgensen and others (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 microorganisms. 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. The propagules are dispersed by wind, animals and other agents. The 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. All alternatives would leave both dead and live trees. This practice would leave a source of propagules for the burned sites in the Moose Fire. The amounts of live and dead trees and their arrangement in the proposed harvest areas are described in Appendix A in the description of treatments.

Vegetation that returns to the harvested sites and the living vegetation that remains on the sites would utilize and store the nutrients released from organic matter. In addition the soil microorganisms also use and store nutrients. These factors reduce the amount of nutrients that would be leached from the site. The amount leached would be similar to the effects of historic wildfires.

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

Timber harvest exposes soils to more sunlight and more moisture. Warm, moist conditions increase microbial activity and the amount of decomposition of organic matter that occurs on a site. In turn, nutrients would be available for plants (Harvey et al. 1994, page11).

Physical Soil Properties - The proposed cutting units where more than 15 percent detrimental soil conditions exist from previous management activities would be further monitored after the Moose post-fire salvage logging. This will be done to measure any additional increase in detrimental soil conditions caused by the salvage activities. At that time, mitigation measures would be implemented to reduce the detrimental soil condition to less than the amount that existed prior to implementing the Moose salvage project. For example, if a unit has 18 percent detrimental impacts before the salvage begins, and 25 percent after the salvage is completed, there must be 17 percent or less

detrimental impacts after implementation of the project and restoration. Restoration would include rehabilitating landings and heavily used skid trails by either ripping, or shrub planting as appropriate for the site.

Harvesting of all other 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 management practices described in Chapter 2 and the BMP Appendix C.

McIver and Starr (2000, p. 14-16 and p. 45-46) discuss the amount of soil disturbance from various yarding systems. Helicopter yarding avoids all impacts from ground-based equipment within a cutting unit. About 1 percent or less of an activity area is disturbed where the trees impact the soil after they are cut. Approximately 10 acres of soil would be disturbed for use as helicopter log landings and service areas. Landings would be located on flat areas away from streams and outside of the cutting units. Helicopter landings would be ripped to lessen compaction and increase movement of water into the soil when they are no longer needed. In some cases, roads would be used for helicopter landings, which would have no effect on soil productivity.

Skyline yarding with either the entire log suspended or with one end of the log suspended disturbs only the skyline corridor where the logs are pulled up hill to a road.

The corridors are narrower than skid trials used for ground-based equipment. They are compacted or displaced, but they occupy about 5 percent of the cutting area. All skyline corridors would have waterbars installed and slash placed on bare soil.

Ground based equipment compacts and/or displaces the soil where it operates. The soils that have moderate burn severity within the Moose Fire area are more susceptible to the effects of ground-based equipment than the soils with low burn severity. Ground based equipment would not operate on soils mapped as high burn severity. The management practices and the design criteria described in Chapter 2 and in Appendix C – BMPS would protect soils and maintain the level of detrimental soil disturbance below the levels cited in the Regional guidelines. The management practices are designed based on burn severity and slope.

Table 3-56: Acres of Proposed Harvest Method by Alternative

Alternative	Acres of Helicopter Yarding	Acres of Skyline Yarding	Acres of Ground Based Yarding on low burn severity	Acres of Ground Based Yarding on moderate burn severity	Acres of Ground Based Yarding on high burn severity
1	0	0	0	0	0
2	1488	795	255	459	0
3	1168	795	270	471	0
4	1054	508	257	329	0
5	1488	795	255	459	0

Roads change soil physical properties. No new permanent roads would be constructed for this project.

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 disturbance from felling trees would be negligible and would be less than the natural amount of soil disturbance caused when trees are uprooted by wind. All trees would either be hand felled towards the skid trails or would be mechanically felled from the skid trails. If the trees blew over in a wind storm the disturbance from uprooting the trees would be greater than the disturbance from cutting the trees. Fuels reduction or site

preparation work 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.

Soil Erosion

Forests generally have very low erosion rates unless they are disturbed. Common disturbances include wildland fire, and harvesting operations. The impact of these operations, however, lasts only for a short time, perhaps one or two years. After that, the re-growth of vegetation covers the surface with plant litter, and potential erosion is reduced. In one study, Robichaud and Brown (1999) reported that erosion rates dropped from almost 40 Mg ha^{-1} the first year after a fire to 2.3 Mg ha^{-1} the second, and 1 Mg ha^{-1} the third year.

Reducing the amount of bare, disturbed soils in harvested areas minimizes soil erosion. The practices that maintain soil productivity, such as leaving organic material on the soil surface and reducing the area impacted by skid trails also reduce the risk of soil erosion. In addition, implementing specific erosion control measures such as waterbars, placing slash on disturbed soils, and vegetating disturbed soils would also reduce erosion.

With the implementation of the management practices described in Chapter 2, the total amount of soil erosion caused by the proposed activities would be small and would decrease with time as vegetation returns to the soils. The WEPP (water erosion prediction project) model was used to estimate soil erosion from post harvest conditions and after implementing the erosion control practices described in Chapter 2.

The results (project record N-12) 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 leaving 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. The WEPP model as it was used for this process does not route or indicate the fate of eroded soil. That information is in the hydrology analysis.

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

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. 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 would happen 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

The proposed road management would have a long-term benefit to soil productivity. All action alternatives would decommission roads. This activity would slowly increase soil productivity on the decommissioned roads. The lack 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 decades to bring productivity levels to what they were previous to road construction. Roads that remain on the forest road system but are closed to use would also see slowly improving soil productivity, but occasional traffic would limit its recovery.

Soil Erosion

Road decommissioning would cause a short-term increase in soil erosion. Disturbed soils adjacent to streams would be at risk of producing sediment. However, decommissioning would be designed to minimize the exposure of bare soils and thus would minimize the amount of soil erosion and sediment. In the long term there would be a net decrease in soil erosion. Sediment production is discussed in detail in the hydrology analysis. Roads that remain on the forest road system but are closed to use 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 of a new road causing a mass failure is eliminated. Roads that are decommissioning will have a reduced long-term risk of road-associated mass failures.

The Risk of Exceeding Soil Quality Guidelines

Detrimental soil conditions would not be significantly increased on the units yarded with helicopter or with skyline systems. Helicopter yarding would disturb one percent or less of the soil surface (McIver and Starr 2000, pages 14-16 and pages 45-46). It would be difficult to see or measure soil disturbance (personal observation, Bill Basko) following helicopter yarding. 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. Most skyline corridors would be reused. If all new corridors were established the total disturbance would be 10 percent at most. Skyline units are unlikely to exceed the Regional guidelines.

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 (Sula State Forest Fire Salvage Monitoring Report, 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 3-55. 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.

Direct and Indirect Effects of Alternatives 2, 3 and 5

Salvage Harvest

Several units that were burned with high fire severity (effects to vegetation) lack fine branches, needles and twigs, important components of an effective slash mat for reducing soil effects. In order to minimize the amount of soil disturbance off skid trails, Alternatives 2, 3, and 5 allow for winter logging in these units. Winter logging is allowable but not required if the proper snow conditions occur.

Temporary Roads

Soil Productivity -Temporary roads would be constructed with Alternative 2, 3 and 5. These alternatives would each build two temporary roads totaling .9 miles (about 2.7 acres of land). The temporary roads would be re-contoured

after use. Soil productivity would be partially restored by re-contouring. Productivity would increase with time as the roads vegetate and organic matter is added to the soils.

Soil Erosion – The risk of soil erosion would increase during use of the temporary roads. After they are re-contoured the risk of soil erosion would be minor because erosion control features such as water bars, logging debris, vegetation and litter would be used on the re-contoured road. Erosion control measures are also integral to improving soil productivity on re-contoured temporary roads.

Direct and Indirect Effects of Alternative 4

Winter logging would not occur in Alternative 4. Several units that were burned with high fire severity (effects to vegetation) lack fine branches, needles and twigs, important components of an effective slash mat for reducing soil effects. In the units that lack these components, winter logging with ground-based equipment would be the best option for maintaining soil productivity and reducing soil erosion. Detrimental effects would be likely on those units if an inadequate slash mat were used to protect soils. This is a concern in units 3, 4, 8, 10, 19, 21, 28, 29, 35, 43, 44 and 62. If the skid trails were spaced closer than 75 feet apart the Regional soils guidelines could be exceeded on these units in Alternative 4. Restoration, such as rehabilitating landings and skid trails, would be necessary to return productivity to acceptable levels.

Temporary roads would not be constructed with this alternative. As a result, the 2.7 acres of proposed road location would not have reduced soil productivity.

Cumulative Effects

Past Actions

Past activities, which affect soils, include timber harvest and its associated activities such as site preparation and reduction of fuels. In addition, road and trail construction have also occurred. These are the main activities that disturb soils in the project area. Approximately 2923 acres of soil are disturbed by past harvest activities and road construction. This represents about 4 percent of the 52,524 acres soil analysis area.

Present Actions

The present actions are firewood gathering and dispersed recreation. Firewood gathering will be closed during the salvage sale. Gathering wood out of burn piles is available at this time, which would have no impact on soils.

Dispersed recreation can compact small areas of soils in or adjacent to recreation sites. However, the overall impact on long-term productivity is small in relation to the size of the watersheds.

Foreseeable Actions

There are two road segments (one in Skookoleel Creek and one in Werner Creek) that are planned for road decommissioning in the summer of 2002. These activities have favorable effects on soils, allowing productivity to slowly increase as vegetation grows, loosening compacted soils and adding organic matter to the soil.

An upcoming NEPA planning process and decision addressing motorized winter access would have no effect on soil productivity.

Re-vegetation and reforestation of sites throughout the Moose Fire area would improve soil conditions by adding organic matter to the soil and by loosening compacted soils.

Installing BMPs to several miles of roads in the Moose area would reduce the amount of erosion from the road. This effects water quality and the drivability of the roads, but has little or no effect on soil productivity.

The installation of larger culverts on roads open year-long or seasonally would reduce the potential for road associated erosion due to culvert failures. This action also would reduce the risk of mass failures in stream channels below culvert failure sites. This activity would have no effect on soil productivity.

Trap trees to control bark beetles could have minor effects on soil productivity. When the trap trees are removed, there could be some compaction, displacement, puddling, or rutting associated with this activity. In addition, the amount of organic debris could be reduced.

Trail maintenance on 21.2 miles of trail would in the long term reduce erosion from the trail, but would have no effect on soil productivity.

Moose Peak Burn, if it occurs, would be done at times when soils are less susceptible to severe burns. This would be when there is moisture in the soil, which reduces the movement of heat down into the soil.

Weed monitoring and possible treatment would help protect the integrity of native plant communities in the Moose fire area. This would protect soil quality on those sites by maintaining plant cover that supplies soil organic matter and cover to protect the soil from erosion.

Road maintenance on 25.5 miles of road would have no effect on soil productivity. It would reduce soil erosion from the road surface.

Road decommissioning would allow soils to slowly increase in productivity as vegetation grows, loosening compacted soils and adding organic matter to the soil.

Commercial mushroom pickers would be dispersed over a wide area. The detrimental effects on soils would be difficult to measure and it would be equally difficult to estimate their effect on soil productivity or erosion.

Measuring the effect would be like measuring the effect of wildlife moving through a forest. Picking mushrooms would not affect mass failure potential.

Recreational public use would continue and increase. The most likely activity to effect soils would be firewood harvest. This activity could reduce the amount of large woody debris along open roads.

Special forest product gathering would have the same effect as commercial mushroom harvesting.

Cumulative Effects Within the Soil Analysis Area (54,524 acres)

The cumulative effects analysis for the Moose analysis 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 3-57 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. In the Spotted Kah, Island Unit and Good Creek analysis areas the total existing disturbance has ranged from 3 to 14 percent.

The calculations used to generate the numbers in the following table are in project record N-15.

Table 3-57: 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. (These acres will project record improved soil productivity and reduced erosion over time)	Total acres Disturbance / % of Analysis Area (52,524 acres in soil analysis area)
1	3015	0	-57	2958/5.6%
2	3015	209	-225	2999/5.7%
3	3015	212	-225	3002/5.7%
4	3015	164	-318	2861/5.4%
5	3015	209	-225	2999/5.7%

The column 'Changes from Road Decommissioning' includes decommissioning occurring from previous decisions that would still occur under the no action alternative.

On an analysis area basis (the Big Creek Watershed), Alternative 4 would potentially reduce soil impacts across the analysis area, because of less acres salvage harvest. The other alternatives would have a small difference in effects.

Cumulative Effects in Activity Areas (cutting units)

Cumulative effects were assessed within each activity area. These effects consist of all past, present, and proposed impacts to soil productivity. All units with previous management activity listed in Table 3-55 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.

Further validation of the existing condition of units with previous management activities will continue in the summer of 2002. Monitoring would occur again following project implementation. The guidance in Forest Service Manual Supplement No. 2500-99-1 (project record N-8) 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 Moose area. Restoration activities such as reclaiming landings and skid trails would be the primary means to restore soil quality.

The Risk of Exceeding Soil Quality Guidelines with a Second Entry

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. 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.

4. 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 (project record N-8) 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.