SOILS

Introduction

The soil analysis process is described in the Soil Analysis Guideline contained in Exhibit H-2. Cumulative effects are discussed in terms of both the analysis area and the activity areas. The Forest Service Handbook FSH 2509.18-2003-1 (Exhibit H-3) defines an activity area as a land area affected by a management activity to which soil quality standards are applied. An example is a harvest unit within a proposed timber sale. Activity areas are a subset of the larger analysis area. The existing condition of the proposed activity areas and the analysis area is described later in this document.

The soils analysis describes the current soil condition and analyzes the soil effects caused by implementation of the proposed management activities. Soil effects are the result of detrimental soil disturbances. Detrimental disturbances are defined in Forest Service Handbook FSH 2509.18-2003-1 (Exhibit H-3) as the condition where established soil quality standards are not met and the result is a change in soil quality. This Handbook also suggests that at least 85 percent of an activity area be maintained in satisfactory soil conditions. Exhibit H-9 explains the background for that standard. The estimated total amount of detrimental soil disturbance based on the existing soil condition and the expected impacts from the proposed activities is presented in Exhibit H-4.

Forest Service Handbook FSH 2509.18-2003-1 (Exhibit H-3), 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.

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.

Differences Between the DEIS and FEIS

This Soils section of the FEIS differs from the same section in the DEIS in that analysis for the new Alternative F was included. Cattle grazing as a cumulative effect on proposed harvest units was included in the FEIS. In addition, literature citations were provided to explain what field observational methods were followed and how soils were classified.

Information Sources

Definitions used in this analysis came from the Forest Service Handbook FSH 2509.18-2003-1 (Exhibit H-3) and the Forest Service Manual FSM 2500-99-1 (Exhibit H-19). The TSMRS database was used to compile a first evaluation of the proposed units that have had previous management activities. The results of those queries are in Exhibit H-22. Field observations were used in addition to the TSMRS queries to determine the existing condition of proposed units. Field data sheets are in Exhibit H-7. Field observations followed the methods described in S. W. Howes, 2001, which is also in Exhibit H-7.

Analysis Area

The analysis area for soils, which encompasses all lands within the boundaries of Logan Creek watershed (61,266 acres), was selected because all proposed management activities would occur within this area and the effects on soils would not extend beyond the project boundary. This analysis area coincides with that used for the Logan Creek Ecosystem Analysis at the Watershed Scale (Logan Creek EAWS) completed in 2001 (USDA, 2001). Information collected for the EAWS, as well as existing Forest Service databases, provided the information used to characterize the affected environment for soil within the project boundary. The analysis area forms the boundary for the cumulative effects analysis of soils.

A landtype map, based on the detailed investigation conducted in the late 1980s, is located in Exhibit H-5. The soils in the project area are described in the updated landtype report for the Flathead National Forest (Martinson and Basko 1998). Landtypes are the basis for the soil analysis. The intent of the taxonomic system is to classify soils according to their limitations that affect specific practical purposes. Classification allows soils to be grouped to permit the largest number and the most precise predictions possible about responses to use and management (USDA Natural Resources Conservation Service 1999). In other words, monitoring results from one taxonomic unit can be related to other similar taxonomic units.

Affected Environment

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)

Soil Productivity

Soil productivity is the ability of the soil to supply the water and nutrients needed to sustain plant growth. Characteristics that influence soil productivity include:

Physical Soil Characteristics – These characteristics include soil depth, the amount of pore space in the soil, and the density of the soil. Changes in these characteristics occur when ground-based equipment makes repeated passes over the soil (Lull 1959). These activities compress or 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 growth through soils, reducing a plant's ability to take up water and nutrients. Compaction and other physical soil disturbances alter the amount of carbon dioxide and oxygen in the soil, affecting both plants and animals that live in or on the soil. Other physical soil disturbances include displacement and rutting.

Most changes in physical characteristics are concentrated on skid trails and landings that resulted from past management activities. Minimizing the area occupied by landings and skid trails would reduce the effects on soil productivity from changes in physical soil properties.

Organic Matter - Organic matter in its various forms improves soil productivity. Humus is decomposed organic matter. Duff and litter are partially decomposed leaves, needles, and twigs that are still recognizable on the surface of soils. Large woody debris consists of woody stems greater than three inches in diameter (Harvey, et al. 1994). Large woody debris supplies moisture to plants after the soils dry out. All organic matter provides water and nutrients for soil organisms and plants. Garrison and Moore (1998) found 85 to 90 percent of the total nutrients in a Douglas-fir tree are contained in the branches, twigs, and foliage. Larsen and others (1981, cited in Harvey, et al. 1999) concluded that fine branches and foliage lost substantial portions of its bound nutrients after a single winter on the ground. These data indicate leaving fine logging slash on the ground for a winter before performing fuel treatment would supply nutrients to the soil and the vegetation that remains on the site.

Soil Organisms - Soil organisms, including fungi and bacteria, drive nutrient cycling by decomposing organic matter, which releases nutrients for plant growth. Soil organisms depend on organic matter for the nutrients they need to carry out their life processes. 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).

The management practices outlined in the features common section of Chapter 2 are designed to do the following:

- Reduce the amount of detrimental soil compaction and displacement by limiting the area affected by equipment operation.
- Leave a variety of organic matter on the soil to provide nutrients and habitat for soil organisms, thus maintaining the processes that drive nutrient cycling.

Soil Erosion

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

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 also remove organic matter from the soil surface. When organic matter is removed, soil pores can be plugged by impact from raindrops resulting in overland flow and soil erosion.

Soil erosion is minimized by implementing the following management practices: reducing the area where equipment operates, locating landings and skid trails on flat ground with a low or moderate erosion hazard, using erosion control features such as water bars, planting vegetation, and placing slash on disturbed soils. Management activities that leave organic matter on the soil surface also reduce soil erosion. Using these management tools in the proposed project would keep soil erosion to a minimum. Detrimental effects caused by soil erosion are long term. The soil lost by erosion can take thousands of years to re-form.

Mass Failure

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

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

Current Conditions

Natural Disturbances

Natural disturbances have affected the soils in the analysis area. Natural disturbances include glaciation, floods, mass failures, drought, insects, plant disease, and wildland fires. These natural processes shaped the soils and landscapes of the Logan Creek analysis area. Natural disturbances are not considered detrimental soil disturbances and are not discussed in the effects analysis.

The most recent wildland fire of size in the Logan Creek Analysis Area occurred in 1940, when 3187 acres burned in the Logan drainage. About 44,000 acres have not burned since 1885 and the rest of the area burned between 1865 and 1920. These fires were within the historic range of fire frequency and are not considered detrimental disturbances. The fires no longer influence the soil productivity, erosion, or stability within the analysis area. Vegetation has returned to the sites and natural soil processes are at work. The effects from wildland fire will not be discussed in the effects analysis. The effects from management fires are included in the effects from timber harvest as displayed in Table 3-53.

Human Disturbances and Existing Soil Condition

Human disturbances include road construction, timber harvest, prescribed fire, fire suppression, and recreational activities. These activities are the basis for the discussion of current conditions and effects of implementing the proposed activities.

Timber Harvest, Roads, and Trails in the Analysis Area

Timber harvesting and its associated road system have caused detrimental soil disturbance in the analysis area. We queried the timber stand and roads databases in order to indicate the extent of these activities and their effect on soils. The roads database also provides the miles of trails within the analysis area. This information is displayed in Table 3-53. Approximately 31 percent of the project area has had past timber harvest, which has altered soil productivity, susceptibility to erosion and the potential for mass failure on a portion of that area. To a lesser degree, firewood gathering, motorized travel, cattle grazing, and recreational opportunities are additional sources of anthropogenic disturbances that affect the Logan Creek watershed.

Table 3-53. Existing Soil Disturbance in the Soils Analysis Area

Acres of soil that has Reduced Productivity from past Timber Harvest	Acres of Land in Roads	Land occupied by the Trail System (acres)	Land disturbed from Cattle Grazing (estimated acres)	Acres/Percent of Soil Analysis Area with Detrimental Disturbance
4994	850	9	275	6054 / 9.9%

The information in the above table is based on information contained in Exhibit H-4. Standards do not exist for the amount of detrimental soil disturbance in an analysis area. However, past analysis across the Flathead National Forest have shown from 3 percent to 13 percent detrimental disturbance.

Soil Productivity - The 4994 acres with reduced productivity from timber harvest consists of skid trails and landings that are compacted and might be rutted or puddled. More acres than this amount were compacted and have recovered due to natural processes such as freeze thaw and root growth. Soil occupied by roads and trails have a reduced level of productivity compared to undisturbed soils. Roads and trails are a dedicated land use allocation that is a result of multiple use of forestlands. These numbers provide a relative idea of the current condition of the soils in the Logan Creek analysis area.

Soil Erosion - Soil erosion in the analysis area is concentrated on roads. Road erosion has direct effects on water quality, but does not affect soil productivity because roads are dedicated to use as a transportation system. Landings and skid trails in the analysis area have all had erosion control features installed, which reduce or eliminate soil erosion. In addition, vegetation has returned to disturbed sites either through planting or natural recovery thus further reducing soil erosion.

Mass Failure - A cut slope slump is associated with Road 313 and originates in proposed Unit 53A. Two rotational slumps are in the Pike Creek drainage above road 9583. All three of these failures occurred long enough ago that they are vegetated and appear to be stable. With the exception of these small areas, the Logan analysis area has stable geology and soils.

Landtype 32, which has a naturally high risk of mass failures (Soil Survey of Flathead National Forest Area, p. 46), does not occur in the Logan area. Slopes greater than 60 percent also have an increased risk of mass failure compared to less steep slopes. The steepest slopes in the Logan area approach 60 percent. However, the typical slopes range from 20 to 40 percent.

Proper implementation of BMPs such as water bars and adequate numbers of ditch relief culverts that disperse water from roads and skid trails reduce the risk of mass failures caused by management activities.

Past Management in Proposed Activity Areas

This section describes the existing condition of the proposed units (activity areas) within the Logan Creek area. The timber stand database was used in conjunction with aerial photographs and field investigations to determine which proposed units had past management activities that caused detrimental soil conditions. Proposed units with previous management activity (Units 21, 23A, 25, 26, 28A) were individually examined on the ground to quantify/qualify the amount of detrimental soil disturbance. Soil disturbance assessment forms from the field investigation are available in Exhibit H-7 for each of the units listed in Table 3-53.

A unit meets the current soil quality guidelines if it has less than 15 percent of its area with detrimental soil disturbance. No proposed activity areas or units currently exceed the soil quality standards.

The lack of detrimental soil disturbance from the past activity could be due to winter logging that protected the soil or due to natural recovery of compacted soils in the time since they were logged. Some of the activities described in Table 3-54 occurred prior to 1960.

All other proposed units have had no past management activities. Their existing soil condition is best defined using the landtype mapping. Landtype information is 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.

Table 3-54. Proposed Logan Cutting Units with Previous Timber Harvest.

Unit Number	Acres in Proposed Units	Previous Activity/Acres of Previous Activity	Date of Previous Activity	Current Soil Conditions	Soil Quality Guideline
21	33	Individual tree cutting occurred throughout the unit. Numerous stumps were observed.	Activity occurred several decades ago. Stumps were old.	No detrimental soil disturbance in the form of skid trails, landings, erosion or mass failures were observed.	Meets
23A	11	Little evidence of prior logging. A 50 foot x 150 foot area was cleared.	Unknown	No detrimental soil disturbance in the form of skid trails, landings, erosion or mass failures were observed. Less than 1 percent of the area has minor soil disturbance that is not detrimental.	Meets
25 & 26	78 & 93	Individual tree cutting throughout the units. Old skid trails and roads are in the central and northern part of units.	Unknown but not recent	Transect measured 1.2 percent of the unit in detrimental soil condition (reduced soil productivity). 8 % of the units had minor disturbance that is not detrimental.	Meets
28A	28	Individual tree cutting in portions of the unit.	Unknown but not recent	No detrimental soil disturbance in the form of skid trails, landings, erosion or mass failures were observed.	Meets

Landtypes and Proposed Management Activities

The following table lists each proposed cutting unit and its landtype. It also lists the soil properties important to management effects.

Landtype productivity, stability, and erosion are from the Landtype Report. The sensitive rating is from the GIS layer for landtypes found in Exhibit H-8. Sensitive soils contain an excess of soil moisture either yearlong or a seasonal basis. Disturbance on sensitive soils can lead to overland flow, soil erosion or loss of soil productivity. Only proposed Unit 101A is on a landtype (14-2) that is rated as sensitive (in spring and times of heavy precipitation). Management practices and mitigation measures would be designed to ensure the Soil Quality Guidelines are met and soil quality is maintained at acceptable levels.

Mass Failures - Mass failures are not a major feature or process in the Logan Creek Drainage. The lack of mass failures is reflected in the Landtype mapping Exhibit H-5, which shows no historic mass failures (landtype 31 or 32).

Table 3-55. Landtypes and Units.

Landtype	Productivity	Stability (cut slopes)	Erosion Surface /subsurface	Sensitive	Units in Landtype
14-2	High	Moderate on road cuts, which are low because the slopes are gentle.	Moderate/severe	Yes, in spring and during times of heavy precipitation.	101A
23-8	Moderate	High	Moderate/moderate	No	114, 115, 76A, 81, 87
23-9	Moderate	High	Moderate/moderate	No	120A, 135, 136, 136A, 137, 137A, 32A, 74A, 76, 76B, 85, 86
26A-7	High	High	Moderate/moderate	No	1, 10, 105, 25, 28A, 300, 4, 63, 66A, 67, 8
26A-8	High	Moderate	Moderate/moderate	No	101, 109, 11, 111A, 112A, 124, 124A, 129, 132, 133, 14, 2, 203, 3, 30, 31A, 33, 34, 38A, 39A, 39B, 45, 47, 5, 50, 53, 53A, 54, 55A, 57, 59, 6, 60, 61, 62, 68, 68A, 69A, 72, 73A, 74, 75, 78, 79, 80, 82, 88, 9
26A-9	High	Moderate	Moderate/moderate	No	47A, 71A, 91
26C-7	High	High	Moderate/moderate	No	15, 16, 17
26C-8	High	Moderate	Moderate/moderate	No	100, 100A, 107, 108, 126, 127A, 128, 131, 18, 19A, 23A, 27, 99, 99A
26C-9	High	Moderate	Moderate/moderate	No	102, 106, 17A
28-7	Moderate	Moderate (steep cuts ravel)	Slight	No	139
56	Low	High	Moderate/slight	No	117, 21, 41, 41A
57-8	Moderate	High	Moderate/slight	No	103, 110, 112, 126A, 127, 134, 200, 201, 24, 29, 301, 32, 35, 38, 39, 40, 42, 43, 44, 48, 49, 51, 52, 56, 58, 64, 65, 69, 71, 73, 77, 7A
57-9	Moderate	High	Moderate/slight	No	123, 130, 132A, 20, 202, 202.1, 302
57-7	Moderate	High	Moderate/slight	No	26, 36, 46, 48A, 70
76	Low	Moderate	Moderate	No	138A, 140

REGULATORY FRAMEWORK

Region 1 Soil Quality Standards (Exhibit H-19) 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 (Exhibit H-19) 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".

Environmental Consequences

Within the Logan Creek Project all proposed activity areas currently meet the guidelines described in Regional Supplement 2500-99-1. No proposed activity area (cutting areas or prescribed burn areas) exceeds or is near 15 percent detrimental disturbance. See Table 3-54 for a summary of the current condition of units with previous activities.

The analysis of effects for soils assumes that all of the practices outlined in Chapter 2, Features Common to All Action Alternatives, would be implemented and would be effective. The analysis will show the expected amount of detrimental soil disturbance resulting from implementation of the alternatives and how that affects soil productivity, soil erosion, and mass failures.

Most of the effects analysis is based on monitoring of past management activities on the Flathead National Forest. Monitoring reports used for comparison purposes were conducted for the same types of activities and were on the same landtypes and soils as those proposed in this DEIS. Almost all of the productive timber ground on the Flathead Forest has an ash surface layer. This makes it possible to extrapolate the results on monitoring in one place to another. In all cases, the monitoring looked at all forms of detrimental soil impacts, including compaction, rutting, puddling, displacement, and erosion. In addition, literature is cited that refers to the aerial extent of detrimental soil disturbance impacts resulting from various harvest systems.

Direct and Indirect Effects of Alternative A - No Action

The No-Action Alternative provides a baseline 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 reclamation, salvage harvest, or fuels reduction would disrupt the natural soil processes.

Organic Matter – With implementation of the No-Action Alternative, all standing dead trees would eventually fall over and contribute coarse woody debris. Needles and branches would remain on the site and fall to the ground. Soil organisms would decompose the organic materials thus adding humus to the soil. Nutrients associated with this material would slowly become available for plant growth. As the tree canopies close in and shade the soil surface, decomposition rates would slow, allowing organic matter and nutrients to accumulate on the soil surface. This process would continue until another major disturbance such as fire or a windstorm opens the tree canopy and speeds up the recycling process again.

Microorganisms – Microorganism populations would fluctuate with the changes in the microclimate and the organic matter on the soil surface. These changes would be in response to the changing vegetation as natural events such as fire, insect, and disease create changes.

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). Sites that are slightly compacted would recover in fewer than 70 years.

Soil Erosion

The No-Action Alternative would allow soil erosion to slowly decrease as vegetation returns to soils that lack plant cover. In some cases natural disturbance such as fire could cause a short-term increase in soil erosion. Soil erosion rates would fluctuate with natural changes in vegetation.

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 and Site Preparation

Soil Productivity

All action alternatives are designed to incorporate management practices that would reduce the effects from timber harvest on soil resources and ensure that all activities meet the Regional Guidelines (Exhibit H-19). The practices are described in Chapter 2 and the BMP Appendix C. The effectiveness of properly applied BMPs is discussed in the opening paragraphs of Appendix C.

Organic Matter – All alternatives would be designed to leave a variety of organic matter on the site; a practice that Harvey, et al. (1994) say maintains productivity. A discussion of coarse woody debris with specific prescriptions can be found in the Vegetation Section located at the beginning of this chapter. By meeting the down wood requirements discussed in the Vegetation section the long term soil productivity will be maintained at levels suitable for growing forest vegetation and soil erosion will be reduced.

Jurgenson, et al. (1981) studied logging followed by low severity slash burning in northwestern Montana. The authors concluded there would be no long-term depletion of nitrogen reserves because lost nitrogen would be more than replenished by inputs from precipitation and by biological nitrogen fixation over a rotation of 100 to 150 years. Harvey and others (1994) note that careful prescribed burns or mechanical site preparation can be practiced on most sites with relatively little effect on soil organic content.

In the same literature Harvey and others state that it is most difficult to resolve the loss of nutrients on sites with high fire potential. The Logan Creek project has several sites where the goal is to reduce the risk of wildland fire by reducing the amount of fuels on the soils surface. In these cases the slash would be removed concurrent with logging, resulting in a reduction of nutrients. Most of these sites are within fuel reduction zones that are adjacent to private lands or are in urban interface areas where leaving the logging slash for a wet season would cause an unacceptable risk of wildland fire. The reduced amount of soil organic matter left in these areas to reduce the hazard of wildland fire in the urban interface would result in a lack of fine debris and result in a risk of having fewer nutrients available for the remaining and future vegetation (Harvey, et al. 1994). This tradeoff is necessary in order to meet the purpose and need for this project. This could affect future tree growth. The units where slash would not be left to leach for a wet season are displayed in Table 3-56.

All harvest prescriptions would leave a portion of the existing stand on the site. What is left behind is described in the Vegetation Section of this DEIS in terms of retention. Light, moderate, and heavy retention would leave about 10, 25, and 50 percent respectively of the trees scattered across the cutting units. Timber management that leaves more trees also leaves more nutrients on the site for sustaining the future forest. Table 3-57 displays the acres of light, moderate, and heavy retention for each alternative.

Table 3-56. Units by Alternative Needing Immediate Slash Disposal.

	Units	Acres
Alternative A:	None	0
Alternative B:	1, 3, 4, 6, 11, 15, 21, 28A, 31A, 41A, 56, 59, 106, 133	1063
Alternative C:	1, 3, 4, 6, 11, 15, 21, 28A, 31A, 41A, 56, 59, 133	985
Alternative D:	1, 3, 4, 6, 11, 15, 21, 28A, 41A, 56, 59, 106, 133	1001
Alternative E:	1, 3, 4, 6, 11, 15, 21, 28A, 31A, 41A, 56, 59, 106, 133	1063
Alternative F:	1, 3, 4, 6, 11, 15, 21, 28A, 41A, 56, 59, 106, 133	1001

Table 3-57. Acres Proposed Vegetation Treatment by Retention Level and Alternative.

Alternative	Light Dispersed Retention	Moderate Dispersed Retention	Heavy Dispersed Retention	Heavy Aggregated Retention
A	0	0	0	0
B	921	4737	966	0
C	430	2686	1225	0
D	342	3191	1199	0
E	829	4232	1255	0
F	523	3093	1809	96

The areas with light and moderate retention would have the least amount of soil nutrients for the future stand of trees. Alternatives B and E have the highest amounts of light and moderate retention and thus have the greatest risk of reducing the nutrient status of the soils. In order to reduce the loss of nutrients in light and moderate retention treatment areas, site preparation in the areas that are not within fuels reduction zones would be delayed for one wet season. This design feature would provide time for most nutrients to leach from the organic debris before it is removed from the site, as recommended by Garrison and Moore (1998).

All fuels reduction using ground-based equipment would be accomplished with tracked excavators operating on or near existing skid trails. This method reduces the aerial extent of soil detrimental impacts from the site preparation activities (Land and Resource Management Plan Annual Monitoring Report, 1992, page 131-139). Where slopes are too steep for ground-based piling equipment, fuels reduction would typically be accomplished by prescribed under burning. Under burning would occur when soils are moist enough to reduce soil heating. Both excavator fuels reduction and under burning would meet the Regional Soil Quality Guidelines. Soil monitoring field sheets from several sites treated in the same manner are in Exhibits H-11 and H-14.

Microorganisms - Jurgenson, et al. (1977) note that after a fire, soil micro-flora recovers quite rapidly, frequently to levels greater than the original. Borchers and Perry (1990) discussed the important role that less disturbed areas of soil play in inoculating soil that lacks or has reduced numbers of soil microorganisms. They state that unburned areas within burns,

adjacent unburned areas, unburned large woody debris, and soils that have only minor amounts of disturbance all contain propagules for fungi, bacteria and other soil organisms and that these propagules are dispersed by wind, animals, and other agents. The organic matter left on the harvest areas would benefit soil organisms by providing substrate and habitat for soil organisms to survive in. All alternatives would leave both dead and live trees. This practice would leave a source of propagules for the disturbed sites in the Logan Creek area. The amounts of live and dead trees to be left in the proposed harvest areas are described in the environmental consequences section of the vegetation analysis.

Vegetation and soil microorganisms remaining in the harvested sites would utilize and store nutrients released from organic matter. This use would reduce the amount of nutrients that would be leached from the site. The amount leached would be less than the loss after wildland fires because of the presence of trees, shrubs, grasses, and forbs left living in the treatment units.

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

Timber harvest increases the amount of sunlight and moisture available to soils. These warm, moist conditions increase microbial activity and decomposition rates, which then increase the amount of nutrients available. However, all proposed treatment areas within the Logan Creek project would retain trees, shrubs, grasses, and forbs. This vegetation would utilize the nutrients before they could leach beyond the root zone (Harvey, et al. 1994).

Management practices discussed above that leave a variety of organic matter on the site and minimize soil compaction would leave a favorable environment for the survival of soil organisms in the Logan Creek areas proposed for treatment. Any reduction of productivity attributable to soil organisms would be unsubstantial and short term.

Physical Soil Properties - Harvesting of all proposed cutting units is designed to ensure detrimental soil impacts affect less than 15 percent of the activity area. This goal would be achieved by implementing the management practices described in Chapter 2 and the BMP Appendix C. These design features and management practices would maintain soil quality by reducing the extent of compaction, rutting, puddling, and displacement.

Unit 101A is the only proposed unit that is identified to occur on a landtype (14-2) that is rated as sensitive (in spring and times of heavy precipitation). This unit would be harvested using skyline yarding and slash treatment would be broadcast burning; this combination would cause the least ground disturbance of any of the proposed treatment methods. In addition, Unit 101A would be whole-tree yarded and hand constructed fireline would be used to contain the broadcast burn.

Both ground-based yarding and skyline yarding would meet the Regional Soil Quality Standards. Ground-based systems usually create more soil disturbance than skyline systems.

Table 3-58. Acres of Proposed Harvest Method by Alternative.

Alternative	Ground-based/ Excavator	Ground-based/ Under burn	Skyline/ Excavator	Skyline/ Under burn
A	0	0	0	0
B	4961	668	462	533
C	3157	472	381	215
D	3827	153	413	311
E	4741	662	439	522
F	4355	355	394	654

Skyline Yarding - McIver and Starr (2000, p. 14-16 and p. 45-46) reviewed the literature on the amount of soil disturbance from various yarding systems. They found skyline yarding disturbed 2.8 percent of the soil in a unit.

Observations on the Flathead National Forest show skyline yarding disturbs only the corridor where the logs are dragged uphill. These corridors are narrower than skid trails caused by ground-based equipment and can be compacted or displaced. Detrimental impacts from skyline yarding are consistently below 15 percent. Monitoring two units on the Riffin Sale on Tally Lake District showed skyline yarding with prebunching of logs by a tracked feller-buncher caused 7 to 9 percent detrimental disturbance on glacial till soils (Exhibit H-10). Prebunching of logs with a feller-buncher is equivalent to following skyline yarding with site preparation by an excavator. These are basically the same piece of equipment with a different tool at the end of the mechanical arm.

Skyline yarding followed by under burning would meet the Regional Soil Quality guidelines. Monitoring of the Riffin sale (Exhibit H-10) showed 7 to 9 percent detrimental soil disturbance from skyline yarding followed by a broadcast burn. In addition, the Doogan Dog sale units 6A and 6B were skyline yarded and then broadcast burned. Monitoring showed they had 9 percent detrimental impacts, which included impacts from an existing road at the bottom of the unit (Exhibit H-12).

Ground-based Yarding – Ground-based yarding that is followed by either underburning or excavator piling would meet the soil quality guidelines. All equipment would operate on dedicated skid trails spaced far enough apart to disturb less than 15 percent of the area including the landing. Soil Monitoring on several timber sale units showed that ground-based equipment operating on dedicated skid trails, followed by excavator piling detrimentally disturbed less than 15 percent of the soil area (Exhibit H-13). Three units on the Haskill sale were logged with tractors on dedicated skid trails followed by excavator site preparation. Monitoring found 7 to 13 percent detrimental disturbance (Exhibit H-14).

Bulk density measurements were taken on several areas where excavators were used to treat fuels and prepare sites for planting. The objective was to determine the effect of excavators on soil bulk density. The results of that exercise (Exhibit H-11) showed excavators increased density less than 15 percent wherever they operated. These results were attributed to low ground pressure. In addition, excavators usually operate on the existing skid trails from yarding.

Another option to reduce the effects of ground-based equipment use is to operate equipment when soils are snow covered, frozen, or dry. Operating equipment under these soil conditions reduces the amount of detrimental soil disturbances. This practice is suggested in FSH 2509.18 – Soil Management Handbook (Exhibit H-3). In addition, Alexander and Poff (1985) and Williams (1993) also discussed the reduced soil disturbance when these conditions are met.

The amount of soil disturbance from both skyline and ground-based yarding systems would be reduced if they occur in winter when soils are either snow covered or frozen. We are not requiring winter logging because the proposed systems would meet the soil quality standards as designed given the soil conditions. The sale purchaser would have the option of winter logging. If that occurs, the amount of detrimental soil disturbance would be less. The monitoring report and field sheets for the Half Moon timber sale (Exhibit H-17) and the Swaney Timber Sale (Exhibit H-18), both logged in winter, show detrimental soil disturbance levels of 2 to 8 percent.

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 recommended in the Regional guidelines.

Duration of Effects - Changes in soil bulk density (compaction) 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) 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 a permanent loss of soil productivity. However, the management practices outlined in Chapter 2 would reduce the amount of displacement and all other detrimental impacts, to within the Region 1 guidelines.

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. 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. Where skid trails already exist from previous activities, they would be reused thus reducing the amount of additional detrimental soil disturbance.

These practices would be minor and short-term changes in soil productivity at levels that would meet the Regional soil quality standards. A few areas would have more substantial changes caused by displacement. These changes would be long term. However, with implementation of the management practices in Chapter 2 and the BMPs in Appendix 3, the long term soil productivity changes together with the short term compaction affects would not exceed the Region 1 Soil Quality Standards. See Exhibit H-23 for a summary of the expected result for each proposed activity area.

Soil Erosion

Forests generally have very low erosion rates unless they are disturbed in a manner that exposes bare soils to the erosive energy of water. Common man-caused disturbances include prescribed fire and harvesting operations. 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 water bars, 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 (Elliot, et al. 2000) was used to estimate soil erosion from post harvest conditions both before and after implementing the erosion control practices described in Chapter 2. The WEPP runs are in Exhibit H-15 and are specific to the soils and climate found in the Logan area. They show that erosion would be reduced about 50 percent with erosion control measures including water bars and placement of slash on disturbed soils. Documentation for the WEPP model is on the internet at forest.moscowfsl.wsu.edu/fswepp/docs/distweppdoc.

All skid trails would have soil erosion control features installed. All skyline corridors would have water bars installed and slash placed on bare soil.

Mass Failure

All proposed activities avoid critical mass failure prone areas in all alternatives. None of the alternatives would cause an increase in mass failures.

Fuels Treatment

Fuels treatment separate from timber harvest would occur in all action alternatives. These treatments would include:

- 566 acres of spring season prescribed under burning of brush fields, forest understory, and other forest vegetation.

Effects - The effects of this treatment would be similar to a low severity wildland fire that reduces fuels while leaving live trees, shrubs, and other forest vegetation behind. Burning in spring would reduce effects caused by high soil heating such as loss of nutrients through volatilization (DeBano 1979 in DeBano, et al. 1999). Soil organisms necessary to recycle nutrients would be available on the burned sites. Organisms would move into the areas under burn piles when soil conditions are recovered enough to provide habitat for the organisms. Ground-based logging equipment would not be used for this treatment, thus soil physical properties would not be changed. These treatments would meet the Regional Soil Quality Guidelines.

- 182 acres of fuels treatment would occur using hand tools and chain saws to cut, move, pile, and burn material where commercial timber harvest or under burning do not occur. Materials to be piled and burned are brush and small diameter trees and existing down and dead fuel.

Effects - The effects of this treatment would be similar to a low severity wildland fire that reduces fuels while leaving live trees, shrubs, and other forest vegetation behind. The effects would include loss of nutrients by volatilization where hand piles are burned. Soil compaction and other physical soil changes would not occur because ground-based equipment would not be used. Some fine organic matter that is a source of nutrients would be lost with a subsequent loss of soil productive potential.

- 3783 acres of precommercial thinning of sapling sized lodgepole pine, western larch, Douglas-fir, spruce, subalpine fir, and a few other tree species in alternatives B, C and E. Approximately 83 acres of these would have hand piling and subsequent pile burning to reduce the risk of wildland fire. Alternatives D and F would have 310 acres of precommercial thinning with 15 of those acres hand piled and burned.

Effects - All material cut in 3700 acres of precommercial thinning would be left on the site to decompose and slowly release nutrients to the soil. This management activity would not impact soil productivity. All work would be accomplished with hand tools, thus there would not be soil compaction or other detrimental changes in soil physical properties. The other 83 acres (or 15 acres in alternatives D and F) would be hand piled and burned. The amount of heat generated by small hand piles is less than that created when large piles burn. As a result, the amount of nutrients that go up with the smoke would be minor. As discussed by DeBano, et al. (1999) the effect would not likely be adverse to soil productivity because nutrient replenishment mechanisms remain on the site. These mechanisms include the presence of nitrogen fixing organisms, both plant and microorganisms, organic matter that is left on the soil surface, and living vegetation on the site.

Road Management

All action alternatives would build new system and temporary roads, as shown in the following table.

Table 3-59. Road Construction by Alternative.

Alternative	Miles of New System Road	Miles of New Temporary Road
A	0	0
B	4.4	5.4
C	2.7	3.6
D	2.7	4.3
E	4.7	4.9
F	3.8	4.5

New system roads are a long-term land use allocation that removes land from productivity. However, roads are needed to carry out the proposed activities in the Logan Creek area. Assuming that a system road occupies four acres of land for each mile of road, 10 to 19 acres of land would be removed from the production of vegetation. This is a long-term change in land use allocation for as long as the road is maintained and not reclaimed. Soil productivity would begin to improve when the roads are reclaimed.

Temporary roads cause a short-term loss of soil productivity lasting several decades. Recontouring, planting grasses, and spreading slash on their surface begin the process of restoring soil productivity. It is possible the soils could be fully functioning in just a few decades. Restoration would occur immediately after the sale was completed.

Soil Productivity

Proposed road management, specifically the reclamation, would have a long-term benefit to soil productivity. Soil productivity would slowly increase on the reclaimed 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. As organic matter accumulates, soil organisms would return and begin cycling nutrients. This process would take decades to bring productivity levels to what they were previous to road construction. All action alternatives would reclaim about 16 miles of roads. 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 the recovery.

Soil Erosion

Disturbed soils where culverts are removed from stream crossings would be at risk of producing sediment after road reclamation. However, reclamation 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 Water Resources 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 establishes on the road.

Road rehabilitation accomplished by adding Best Management Practices to existing roads would effectively reduce the amount of soil erosion from those roads by providing places where water would run off the roads into vegetation where the water soaks into the soil and sediment is trapped. This is not a soil productivity issue, but a road maintenance and a water quality issue. Roads are not expected to be productive sites for forest vegetation.

Mass Failure

New permanent and temporary roads would all avoid sites with a high risk of mass failure. Roads that are reclaimed would have a reduced long-term risk of road-associated mass failures. Roads that are rehabilitated have improved drainage of surface water, which spreads the water over a larger area and disperses it. This practice reduces the risk of road-related fill failures.

Cumulative Effects Common to All Action Alternatives

Past Actions

Past activities that 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 6119 acres of soil have been disturbed by past activities. This represents about 9.9 percent of the 61,266-acre soil analysis area.

Timber harvest – Many thousands of acres of timber has been harvested on federal, state, and private land since early in the last century. This harvesting has ranged from individual tree removals to complete clear cuts. The vast majority of these acres have regenerated into new forests. The acres of past timber harvest are included in Table 3-60.
Road Construction – Several hundred miles of road have been built on federal, state, and private land since the beginning of the last century. Road construction removes soil from being productively adding to the vegetated forest community. This is a necessary trade off so forest management can occur. The acres removed from productivity are included in Table 3-60, which summarizes all past activities in the Logan Creek area.
Trail Construction - Trail construction, like road construction, removes soil from being productively adding to the vegetated forest community. This is a necessary trade off for recreation activities. The acres removed from productivity are included in Table 3-60, which summarizes all past activities in the Logan Creek area.
Precommercial Thinning – About 4300 acres of sapling-sized stands have been thinned since the 1960s. Precommercial thinning does not use tracked or wheeled equipment and thus does not compact or displace or otherwise cause detrimental soil disturbance.
Fish Stocking – No effect on soils.
Wildland Fire – Creates temporary increase in erosion. All past wildland fires in the Logan Creek area are currently vegetated and thus are assumed there were no lasting detrimental impacts to the soil resource.

Past, Present, and Reasonably Foreseeable Actions:

Grazing – Approximately 2750 acres of the 9200 acre Chinook Lake Cattle allotment is within the Logan Creek area. Cattle have been grazed on this allotment for many years and would be permitted in the future. Some amount of detrimental soil disturbance has resulted from cattle grazing mostly in the form of trails that are compacted and subject to soil erosion. Based on monitoring of other allotments on similar soils, detrimental soil disturbances from grazing would amount to at most 10 percent of the area (about 275 acres) in a worse case situation. These areas occur where roads intersect with streams, a situation that provides cattle with easy access to riparian areas and water and are dispersed throughout areas where timber was harvested in the past.
Private Land Development – The construction of roads and buildings on private land has been occurring for decades and will continue. The rate of development on private land has been recently increasing. This activity is not considered as part of the soil analysis

because it occurs off lands managed by the Forest Service and the effects of private land management do not affect the soils on lands managed by the Forest Service.

Wildland Fire Suppression – Since about 1940, the Forest Service and State of Montana have actively suppressed wildland fires. These agencies will continue to suppress wildland fire. As a result of this fire suppression, soils have been detrimentally disturbed by the construction of fire lines and other features needed to control wildland fires. After a fire is put out, fire lines and other soil disturbances are restored or rehabilitated. This activity does not totally restore soil quality, but it does begin the process leading towards improved soil quality.

Noxious Weed Treatment – The Forest Service, Flathead County, and private citizens have conducted weed treatments for many years. This activity will continue. This treatment has a positive effect on soils by increasing the cover of desirable plants. These plants provide more ground cover than most weeds, thus reducing the risk of soil erosion and encouraging the development of soils that are rich in organic matter and better able to cycle nutrients.

Hunting, Fishing, Trapping - These dispersed activities have little effect on soils. Some small amount of soil compaction or erosion may occur result from them, but given the size of the analysis area their effect is not measurable.

Firewood Gathering - This dispersed activity has little effect on soils. A small amount of soil compaction may occur, but given the size of the analysis area its effect is not measurable. Firewood cutting could reduce the amount of large woody debris available for future recruitment. This would most likely occur adjacent to roads where firewood cutting is allowed. Within those areas, the future soil productivity could be reduced. It is not possible to estimate the effect on soils in the analysis area.

Snowmobiling – This activity will continue to occur. Snowmobiling is not as popular on the Tally Lake Ranger District as other parts of the Forest. Small areas of soil disturbance could result if snowmobiles operate where there is shallow snow cover. The effect is more likely to result in soil erosion if the slopes are 50 percent or greater. Effects on soil productivity would be limited to the areas disturbed and would occur only if erosion of the nutrient rich topsoil occurred. The result across the analysis area would be difficult to measure.

Camping/Boating – Tally Lake Campground will continue to be one of the most popular campgrounds on the Forest. Tally Lake will continue to receive a substantial amount of recreational boat use. Dispersed camping is less popular, but will continue. The designated campgrounds are allocated for recreation use and as part of that use, some soil detrimental impacts, mostly soil compaction, are accepted. This effect is not included in the cumulative effects analysis.

Driving, Motorized Trail Riding – Driving and sightseeing on open Forest roads will continue. Many trails in the project area have been and will continue to be open to motorcycles. These activities have no measurable effect on soil productivity in the analysis area. They can increase soil erosion from the roads and trails where they occur.

Mountain Biking – This activity has occurred and will continue to occur on both trails and roadways. This activity has no measurable effect on soil productivity in the analysis area. It can increase soil erosion from the trails where it occurs.

Hiking – This activity has no measurable effect on soil productivity.

Road Maintenance – This activity has no effect on soil productivity in the analysis area. It would reduce the amount of erosion from the road surface.

Trail Maintenance – This activity has no effect on soil productivity in the analysis area. It would reduce the amount of erosion from the trail surface.
Re-vegetation and Reforestation - This activity would improve soil conditions by adding organic matter to the soil and by loosening compacted soils.
Installing BMPs - This activity 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.
Bark Beetle Trap Trees – This activity 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. However, the number of trees is small relative to the analysis area.

Cumulative Effects Within the Soil Analysis Area

The cumulative effects analysis for the Logan area includes the effects of both existing soil disturbances from past activities and the expected disturbances from the proposed activities. This analysis 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 3-60 displays the estimated cumulative 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 purposes the Spotted Kah, Island Unit, and Good Creek analysis areas had total existing disturbance that ranged from 3 to 14 percent.

Table 3-60. Cumulative Effects of Past, Present, and Proposed Treatments on Soil Analysis Area by Alternative.

Alternative	Existing disturbance (cattle grazing, roads, trails and timber harvest) in acres	Proposed Disturbance Including Skid trails, Landings and Fuels Reduction Treatments	Changes from Road Reclamation in Acres. (These acres would result in improved soil productivity and reduced erosion over time)	Total acres Disturbance / % of Analysis Area (61,266 acres in soil analysis area)
A	6119	0	65	6054 / 9.9%
B	6119	875	65	6929 / 11.3%
C	6119	568	65	6622 / 10.8%
D	6119	628	65	6682 / 10.9%
E	6119	838	66	6892 / 11.2%
F	6119	729	66	6782 / 11.1%

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

Compared to the other action alternatives, Alternative C would potentially cause the least soil impacts across the analysis area because of fewer acres of timber harvest. The other

alternatives would impact soils slightly more than Alternative C. However, all alternatives are designed to meet the Region 1 Soil Quality Standards.

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 3-54 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. The estimated cumulative effects for each activity area from implementation of an action alternative are in Exhibit H-23. As the project is currently designed, all proposed activities would meet the Regional Soil Quality Standards.

Monitoring would occur again following project implementation using the procedures described by Howes (Exhibit H-21). Forest Service Manual Supplement No. 2500-99-1 (Exhibit-19) 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 Logan Creek area. Restoration activities such as reclaiming landings and skid trails by ripping and planting with shrubs would be the primary means to restore soil quality.

Cattle grazing in the Chinook Lake allotment has taken place in the past on proposed timber harvest areas. The following table summarizes which units and how many acres are affected by past cattle grazing.

Table 3-60a. Cumulative Effects of Cattle Grazing on Proposed Timber Harvest areas by Alternative.*

Alternative	Total acres of proposed timber harvest in the Chinook Lake allotment	Timber harvest units in the Chinook Lake allotment
A	0	N/A
B	301	6, 7A, 9, 10, 11, 14
C	192	6, 7A, 9, 10, 11
D	174	6, 7A, 10, 11
E	301	6, 7A, 9, 10, 11, 14
F	250	6, 7A, 9, 10, 11, 14

Allotment maps with timber harvest units are located in Exhibit H-24.

As discussed above, cattle primarily graze on or near roads and in the vicinity of streams. Cattle would not be expected to spend much time in the forested areas proposed for timber harvest due to the dense nature of the trees and accumulated downfall. Estimates of impact to soils from other forested areas on the Flathead National Forest show no more than one percent has been detrimentally affected. These estimates are based on visual observations of past

harvest areas where cattle have grazed. Effects to soil from cattle are primarily the removal of upper layers of organic material and where use is concentrated, compacted soils. Timber harvest activities coupled with cattle grazing impacts would not exceed 15 percent detrimental soil conditions.

The Risk of Exceeding Soil Quality Guidelines with a Second Entry

The greatest risk of exceeding the 15 percent disturbance standard would be on Units 25 and 26, which have about 1.2 percent existing detrimental soil disturbance. However, by reusing existing skid trails and landings from past management and implementing the other design features in Chapter 2, these units are expected to meet the standards of 15 percent. If detrimental soil disturbance occurs on 15 percent or more of any unit, restoration would occur to reduce the amount of disturbance to 15 percent.

Restoration Effectiveness

Soil restoration activities would occur if monitoring shows that the amount of detrimental disturbance exceeds the Regional guideline of 15 percent aerial extent. 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 and Consistency at the end of this section). Several studies discuss the effectiveness of ripping as a soil restoration activity. Studies cited by Froehlich and McNabb (1983) showed up to 39 percent improved seedling survival and growth after tilling compacted soils. The same study showed height growth gains of 8 to 73 percent.

A publication by the British Columbia Ministry of Forests (Bulmer 1998) 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) and improve the environment for soil organisms. The goal of soil restoration is to set the stage for the soil to begin the recovery process. Soil restoration is not an immediate result of ripping, planting, or any other activity.

REGULATORY CONSISTENCY

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