3.6 Soils

Introduction

This section describes the soil resources in the Como Forest Health project area in terms of:

- Existing soil condition - the extent of Detrimental Soil Disturbance (DSD) from past and present management activities in activity areas (treatment units); and
- Environmental consequences - the potential for proposed and alternative management activities to create additional DSD in activity areas.

Detrimental Soil Disturbance (DSD) is defined in Forest Service Manual, FSM 2500; R-1 Supplement No. 2500-99-1 (PF-SOILS-001). This document also outlines the soil quality standards for Region 1, referred to as R1 SQS.

3.6.1 Overview of Issues Addressed

Disturbances to soils from compaction and displacement of organic matter and topsoil by management activities may reduce soil productivity in the project area. Past timber harvest and site preparation for planting in the area has resulted in legacy compaction of soils in some of the proposed activity units. Proposed commercial thinning treatments must be designed to ensure long-term soil productivity is maintained within treatment units.

3.6.1.1 Issue Indicators

DSD is the measurement indicator for soils in the activity areas or treatment units. DSD from proposed activities in this project will primarily be the result of soil displacement and compaction from mechanized timber yarding and log hauling. Soil analysis will focus on site specific DSD within proposed treatment units. Soil productivity will also be discussed in relation to DSD and other existing site conditions.

3.6.2 Assessment of Existing Soil Condition and Detrimental Soil Disturbance

The Soil Scientist assessed Como Forest Health project proposed treatment units through field reconnaissance, satellite image interpretation, and GIS data analyses. Method of assessment was based upon a number of factors, including:

- Potential to use ground-based harvest and yarding activities as a function of slope gradient. Currently, the Bitterroot National Forest Plan (Forest Plan) does not allow for ground-based yarding on slopes steeper than 40 percent. To reduce disturbances further, ground-based yarding operations on the Bitterroot National Forest (Bitterroot NF) are generally restricted to slopes less than 35 percent.
- Potential for proposed treatments to cause detrimental disturbances to specific soil types in the area. Summer ground-based yarding typically incurs some of the highest soil disturbance of forest management activities whereas prescribed burning treatments are typically of low severity and have a low risk of affecting soil productivity.

- Occurrence of documented previous harvest activities, based upon records in the FACTS database. This database documents the date and kind of silvicultural treatment performed on timber stands in the Como project area (Table 3.1-8).

3.6.2.1 Field Measurement Methodology:

The proposed treatment units were field reviewed using a walkthrough survey to get an overview of each unit. The surveys identified past management activities such as timber harvest that still result in DSD. Soil surveys followed guidance provided in the documents listed below. These documents can be found in PF-SOILS-002.

- The Region 1 Approach to Soils NEPA Analysis Regarding Detrimental Soil Disturbance In Forested Areas – A Technical Guide, March 2009
- Forest Soil Disturbance Monitoring Protocol, Volume 1 Rapid Assessment. USDA Forest Service. Gen. Tech. Report WO-82A. September 2009
- Soil –Disturbance Field Guide. USDA Forest Service. National Technology & Development Program. 0819 1815-SDTDC. August 2009.

3.6.3 Regulatory Framework

The Bitterroot National Forest Land and Resource Management Plan (Forest Plan, 1987), FSM 2500, and FSM 2550 provide direction for the management of soils within activity areas. This direction can be found in the following documents. A detailed description of the Regulatory Framework can be found at the end of the soils section.

- The National Forest Management Act
- The Bitterroot National Forest Plan (USDA Forest Service 1987)
- Forest Service Manual (FSM 2550)
- FSM 2500 – R-1 Supplement R1 2500-2014-1 and R1 2509.18-2003-1
- Montana State Guidelines for Best Management Practices (BMPs)
- Soil and Water Conservation Practices (SWCPs) Handbook 2509.22
- Executive Order 11990

3.6.4 Affected Environment

3.6.4.1 Existing Condition

The project area is located at the base of the Bitterroot Mountains in highly glaciated terrain. The area is bordered by the Lost Horse drainage to the north and the Rock Creek drainage to the south, both of which are some of the most heavily glaciated drainages on the forest. The latest glaciation ended approximately 11,000 years ago. The majority of the project area is located in the Lick Creek drainage, which is a small watershed (less than 6,000 acres) that has limited contributing area. The Lick Creek watershed is defined by steep mountain slopes along the Bitterroot front that extend onto glacial moraines deposited by piedmont glaciers that coalesced from the Rock Creek and Lost Horse drainages (Weber, 1972). Lick Creek and associated tributaries flow to the east and drain directly into the Bitterroot River at the east end of the watershed.

The glacial moraines in the project area were deposited at the base of the Bitterroot Mountains with depositions extending to the Bitterroot River. Glacial events have

occurred numerous times with two distinct moraines recorded in the project area – Judd and Charlos Drifts (Weber, 1972). The topography is typically gentle on top of the moraines with steep sideslopes primarily along the north and south sides of the moraines. The topography is complex in various areas due to the advance and retreat of glacial ice. There are relic features including kettles, proglacial lakes, and various drainage ways and outwash plains. Lake Como is a morainal lake where water has been impounded behind the end moraine from Rock Creek and Lost Horse glaciers. The capacity of the lake has since been increased with an earthen dam that rests on top of the end moraine to provide irrigation water for much of the Bitterroot Valley.

The glacial soils are typically coarse textured, derived from granitic parent material carved from the Rock Creek and Lost Horse drainages. However, pockets of fine textured soils with high concentrations of silt can be found in relic kettles and proglacial lake depositions. Wetlands that have formed in some of these glacial features have thick organic horizons. Some of these soils are classified as histosols which are not commonly found in the Bitterroot Valley. Other glacial features include large erratics (boulders) scattered across the landscape. The erratics are found on the surface and many are buried deep within the moraines.

Deep soils with coarse surface textures can be sensitive to erosion if ground cover consisting of litter, duff, and vegetation are damaged or removed. Recovery of these soils occurs at a faster rate than the shallow soils on ridgelines and south facing slopes due to biomass production and subsequent soil organic matter accumulation.

South and west facing aspects typically have shallow soils (less than 10 inches to bedrock/parent material); this is especially true along the tops of moraines and along south facing slopes of lateral moraines. These areas are often associated with cliffs and exposed rock outcrop. The shallow soils have lower site productivity, lower vegetative cover, and inherently lower effective soil cover than more developed, deeper soils on north and east facing slopes. The protective litter and duff layer of these soils is often discontinuous and less than 1 inch thick. Due to dry and low productivity soils, grasslands are often found along ridgelines and south facing slopes. Soil properties are included in PF-SOILS-003.

The potential for compaction with ground-based equipment on these shallow, coarse textured and high coarse fragment content soils is low to moderate. The high amount of coarse fragments in these soil types limits the ability of ground-based equipment to compress soil particles, since the equipment is supported primarily by rock. Inclusions of soils with fine surface textures - loamy, fine-loamy, and fine control sections, occur in the project area and can be sensitive to soil compaction from ground-based harvest equipment. Displacement of duff and organic horizons are of a much greater concern since soil development is minimal. Soil productivity in these shallow soils is dependent on the organic soil horizons for nutrient cycling and water holding capacity. Design features (Chapter 2) have been prescribed for ground-based yarding to address potential risks to soil productivity. All proposed commercial thinning treatments will be implemented under timber contract provisions, which include soil and water resource protection listed in the Montana Best Management Practices for timber harvest and the Soil and Water Conservation Practices (SWCPs) (FSH 2509.22)

The Forest Plan determines suitable land (areas suitable for timber management) with the recognition that there are unsuitable land inclusions within this broader designation. The

identification of these inclusions and their significance is left to the project level. Determination of suitability within each unit was completed based on the following language in the National Forest Management Act of 1976, Section 4, "It is the policy of the Congress that all forested lands in the National Forest System shall be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans." As stated in the Bitterroot National Forest Plan (Forest Plan), thinning can occur on unsuitable lands to meet the goals and standards of the management area (Forest Plan p. III-5(e (8)) p. III-18(e (7))) and meeting cover/forage objectives (Forest Plan p. III 11(e)(1)).

Table 3.6- 1 shows the dominant landtype map units that occur within the proposed activity areas. Only dominant landtype map units within the boundaries of the treatment units were considered; small map units that made up less than 15 percent of a treatment unit were considered too small to affect overall management prescriptions. The data in Table 3.6- 1 is derived from the Bitterroot National Forest Soil Survey. This soils data can be obtained from the NRCS Web Soil Survey tool (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).

Table 3.6- 1: Dominant Landtype Map Units Found within Proposed Treatment Units

* Landtype Map Unit Symbol	Landtype Map Unit Name	Landform	Parent Material	Dominant Texture	** Found in Proposed Units
17B33	Crow-Haugan-Curlew families	Erosion remnants, Drainages	Colluvium, Alluvium	Gravelly loam	1, 3, 6, 9, 17, 38, 39, 43, 74, C2
30B18	Kadygulch-Totelake families	Steep Mtn slopes	Colluvium derived from granite	Gravelly sandy loam	45, 46, 51
30D18	Leighcan family	Steep Mtn slopes, moist	Colluvium derived from granite	Gravelly sandy loam	45, 51
30D30	Tolby Agneston families	Steep Mtn slopes	Colluvium derived from granite	Gravelly sandy loam	1, 3, 4, 5, 6
30G18	Leighcan family	Steep Mtn slopes, moist	Colluvium derived from granite	Gravelly sandy loam	51
31B15	Totelake-Macmeal-Sharrott families	Dissected Mtn Slopes	Colluvium derived from granite	Very gravelly sandy loam	48, 49, E2
31B70	Macmeal-Kadygulch-Tolman families	Dissected Mtn Slopes	Colluvium derived from volcanic rock	Gravelly sandy loam	39
44B16	Repkie-Losthorse families	Moraines	Till derived from granite and gneiss	Very boulder ashy loam	11, 18, 19, 20, 21, 22, 23, 26, 36, 53
44B32	Yreka-Repkie-Curlew families	Moraines	Till derived from granite and gneiss	Bouldery loam	1, 8, 9, 12, 13, 14, 15, 16, 32, 34, 38, 47, 53, 57, 58, 59, 60, 61, 62, 64, 65
44D41	Roman-Priestlake-	Moraines	Volcanic Ash over Till derived from	Bouldery Ashy Loam	24, 25, 26, 27, 41, 42, 52, 66

* LANDTYPE MAP UNIT SYMBOL	LANDTYPE MAP UNIT NAME	LANDFORM	PARENT MATERIAL	DOMINANT TEXTURE	** FOUND IN PROPOSED UNITS
	Lilylake families		granite and gneiss		
47B13	Repkie-Losthorse-Curlew families	Moraines on glacial valley floors	Till derived from granite and gneiss	Very boulder ashy loam	10, 42, 50, 66, 70, 73, 75, A, B2
49B15	Jeru-Shermount families	Glacial valley walls	Colluvium and/or till derived from granite and gneiss	Very stony sandy loam	46, 47

* Descriptions of the Landtype Map Unit Symbols are located in the project file (PF-SOILS-003).
** Dominant Landtype Map Unit located within unit –comprises greater than 15 percent of the unit.

Soil textures are dominantly coarse textured with some soils having some finer textured silt loam horizons. Coarse fragment content of these soils is high in most areas due to soil development from unconsolidated glacial deposits.

Site Conditions in Treatment Units

Field surveys of soil conditions were performed by a professional soil scientist in all proposed treatment units within the Como project area during the summers of 2009 through 2012. Refer to the Field Measurement Methodology section for survey methods and assumptions. DSD was identified in some of the proposed treatment units (Table 3.6-2).

Table 3.6- 2: Existing Condition of Proposed Treatment Units. Data Based on Region 1 Soil Monitoring Protocol Completed by Professional Soil Scientist.

PROPOSED UNIT	UNIT AREA (ACRE)	DSD (% IN UNIT*)	EXISTING DSD (ACRE)	PROPOSED UNIT	UNIT AREA (ACRE)	DSD (% IN UNIT*)	EXISTING DSD (ACRE)
1	42	5	2.1	41	24	0	0.0
3	20	2	0.4	42	25	2	0.5
4	10	0	0.0	43	32	3	1.0
5	24	0	0.0	45	86	2	1.7
6	21	0	0.0	46	14	0	0.0
8	38	0	0.0	47	5	0	0.0
9	21	5	1.1	48	5	0	0.0
10	59	2	1.2	49	45	5	2.3
12	199	5	10.0	50	47	2	0.9
13	57	0	0.0	51	47	0	0.0
14	88	0	0.0	52	9	0	0.0
15	3	0	0.0	53	249	5	12.5
16	17	0	0.0	57	29	2	0.6
17	21	2	0.4	58	4	0	0.0
18	29	5	1.5	59	5	0	0.0
19	14	0	0.0	60	21	0	0.0
20	8	2	0.2	61	35	5	1.8
21	12	0	0.0	62	30	2	0.6
22	74	2	1.5	64	57	0	0.0
23	79	2	1.6	65	17	2	0.3
25	15	0	0.0	66	27	0	0.0

PROPOSED UNIT	UNIT AREA (ACRE)	DSD (% IN UNIT*)	EXISTING DSD (ACRE)	PROPOSED UNIT	UNIT AREA (ACRE)	DSD (% IN UNIT*)	EXISTING DSD (ACRE)
26	52	5	2.6	66A	19	0	0.0
27	26	0	0.0	73	5	2	0.1
28	50	2	1.0	74	6	2	0.1
32	9	2	0.2	75	3	0	0.0
34	17	0	0.0	A	25	0	0.0
36	204	20	40.8	B2	124	0	0.0
38	34	2	0.7	C2	104	0	0.0
39	101	5	5.1	E2	31	0	0.0
40	7	0	0.0				
Total = 2,481 acres		Max = 20%		Total DSD = 93 acres			

* This column represents the amount of DSD within the proposed treatment units (FSM and Region 1 Handbook definitions) and thus directly equates to Region 1 soil quality guidelines.

Evidence of past ground based operations was noted in several units primarily from old skid trails where root limiting soil compaction is still present. Past displacement of organic horizons has naturally recovered due to the new development of duff and surface organic horizons. Organic horizons and duff on the old skid trails resembled that of adjacent undisturbed areas.

Unit 36 is a plantation that was clearcut and dozer scalped to prepare for planting in the 1980s. The skidding and dozer scalping operations displaced and mixed organic material and top soil horizons with the subsoil. The activities also created excessive soil compaction. This unit currently has 20% DSD levels and requires treatment that will lead to improvement in soil productivity in order to carry out further vegetation management in this unit.

3.6.4.2 Desired Condition

As required by NFMA Section 6 (g)(3)(C), the Forest Service must assure that project activities do not produce substantial and permanent impairment of the productivity of the land (FSM 2550.05). Additionally NFMA requires that timber will be harvested from National Forest System lands only where soil, slope, or other watershed conditions will not be irreversibly damaged.

The R1 SQS assures this statutory requirement is met. R1 SQS were developed by selecting soil characteristics that are influenced by management activities affecting soil productivity. R1 SQS provide benchmark values that indicate when changes in soil properties and soil conditions would result in significant change or impairment of soil quality based on available research and Regional experience (FSM-2550). The soil characteristics selected as indicators of management influence on soil productivity are:

- compaction,
- rutting,
- burn severity (FSH 2509.13, chapter 23.32),
- displacement,
- surface erosion

- mass movement[1].

When these indicators are found, the soil is considered disturbed. When management activities cause the indicators to exceed the threshold established in the R1 SQS, the disturbance is considered detrimental (potentially impairing productivity). The R1 SQS state that new activities will be designed so that they do not create detrimental soil disturbance (DSD) on more than 15% of an activity area (R1 Supplement to FSM 2554.03, PF-SOILS-001). In other words, existing DSD plus the DSD predicted for proposed activities (cumulative DSD) should not exceed 15% of a given activity area. In areas where more than 15% DSD exists from prior activities, the cumulative detrimental effects should not exceed the conditions prior to the planned activity and should move the site toward a net improvement in soil quality.

3.6.5 Environmental Consequences

Soil disturbance is an unavoidable consequence of forest management activities. Montana BMPs, SWCPs, design criteria, and mitigations are applied to reduce disturbance and limit the effects of resource management activities on soil resources; however, it is not possible to completely eliminate disturbance. Management activities can result in both direct and indirect effects on soil resources. Direct and indirect effects may include alterations to physical, chemical, and/or biological properties. Physical properties of concern include structure, density, porosity, infiltration, permeability, water holding capacity, depth to water table, surface horizon thickness, and organic matter size, quantity, and distribution. Chemical properties include changes in nutrient cycling and availability. Biological concerns commonly include abundance, distribution, and productivity of the many plants, animals, microorganisms that live in and on the soil and organic detritus.

Impacts known to cause the greatest adverse effects on physical, chemical, and biological soil properties include soil compaction, displacement, puddling, burning, erosion, and mass wasting. Direct effects of management activities commonly include compaction, displacement, puddling, and burning. Erosion, mass wasting, and changes in water table, soil biology, organic detritus recruitment, and fertility (such as the fertilization effects of ash after a light-severity fire) usually occur as indirect effects.

3.6.5.1 Methodology

Direct and indirect effects of the Alternatives and associated activities on soil resources will be analyzed in terms of:

- Soil productivity; and
- Detrimental soil disturbance (DSD) by activity areas.

Cumulative effects will be considered for all past, proposed, current and reasonably foreseeable activities within activity areas.

[1] Mass movement is defined in the R1 Supplement to FSM 2554 as “the detachment and downslope movement of soil or the surface mantle in the form of debris slides/avalanches or deep seated rotational failures or slumps”. Some types of mass movement may improve soil productivity. (E. G. Soil creep or a rotational slump may improve aeration on some soils.) When the mass movement improves soil productivity, do not include them in the areal extent of detrimental soil disturbance. Manage these areas to maintain slope stability, water quality and ecosystem functions.

The primary concerns are direct and indirect effects of management activities on soil productivity and disturbance (Forest Plan Forest-wide Management Standards 2.h.3, 5, 6, 7, 8, and 9). The magnitude of productivity loss associated with any action is influenced by the degree, extent, and duration of adverse soil conditions within and adjacent to each activity area. Degree refers to the magnitude of change in soil properties, such as an increase in bulk density or a decrease in macroporosity, and the depth to which those changes occur. Extent refers to the area affected by such changes. Duration refers to the length of time such changes may persist on or adjacent to the site.

The criteria used to determine direct, indirect, and cumulative effects on soil productivity is the percentage of area within an individual treatment unit where DSD has occurred or is anticipated from proposed activities (PF-SOILS-001 and 002).

Spatial and Temporal Context for Effects Analysis

Treatment units are considered the activity areas for which direct, indirect, and cumulative effects on soil productivity are analyzed. Soil productivity is a site specific characteristic. Loss of soil productivity in a treatment unit alone will not lead to a loss of soil productivity in an adjacent stand or other areas across a watershed. Soil productivity is a site-specific variable and dependent on a number of climatic characteristics and soil forming factors that occur at very small scales. Soil productivity can vary from one square foot to the next with each area functioning independently. Thus, the highly variable and independent nature of soil productivity requires site-specific analyses to maintain the proper context. Assessment of cumulative effects on soil productivity at scales larger than the specific treatment unit boundary (such as the watershed scale) also misrepresents the effects of management activities by diluting the site-specific effects across a larger area. In contrast to soil productivity, processes such as erosion regime and hydrologic functions occur at the watershed scale and are analyzed in the Hydrology Section.

Detrimental soil disturbances from harvest activities such as skidding, temporary road construction, track line machine trails, skyline yarding, and landing operations are not expected to persist beyond 5-10 years when rehabilitation activities are completed. Detrimental effects may persist up to 50 years on heavily compacted areas such as heavily used skid trails and landings that are not rehabilitated. Detailed discussion is outlined in Direct and Indirect Effects to Soils.

In the past, soil damage was considered irreversible where forest resources are committed to the forest transportation system, administrative sites, recreation facilities, and mining operations. Irreversible effects to soils can be reversed through road decommissioning and other reclamation projects if forest management chooses to return these sites back to the productive land base.

Connected Actions, Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis

Discussion concerning the amount of area in the project area previously harvested and effects on the soil resource at the landscape scale is included in the Soils Section 3.6.5.4 - Cumulative Effects for All Alternatives.

3.6.5.2 Alternative 1 – No Action

Direct Effects

Alternative 1 is the no action alternative. This alternative maintains the existing condition of the project area and 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 and soil disturbance.

Soil Productivity

Soil Erosion and Mass Movements

The No Action Alternative would not alter the current soil erosion and mass wasting regimes in the project area. Natural and human caused wildfires will likely continue to affect the project area and cause consumption of the protective layer of litter and duff on the soil surface (background information on the 2000 fires and erosion are provided in PF-SOILS-004).

The occurrence of substantial levels of soil erosion and mass movements on the forest has been low where low severity fire has occurred (based on monitoring conducted on the forest over the last 15 years). Larger fires and those of moderate or high severity may cause soil erosion and mass movement depending on ground conditions and storm activity (Parrett et al. 2003). Soil erosion occurs where ground cover, duff, and litter are consumed or hydrophobic soil conditions develop. Mass movement occurs primarily in the form of debris torrents within channels following high severity, short duration storm events (Background information on debris torrents provided in PF-SOILS-004).

The potential for mass movement may increase in areas where structural support from tree roots is lost. Steep, north facing slopes with soils derived from glacial till (particularly slopes that extend into the Lost Horse drainage) are the most susceptible to mass movement.

Organic Matter, Groundcover and Coarse Woody Material

The No Action Alternative would allow all standing trees (dead and alive) over time to shed needles and fine branches that would accumulate on the soil surface. Eventually, trees would fall to the ground, providing coarse wood for decomposition into the soil. Soil organisms would slowly decompose the organic materials, adding beneficial humus to the soil. The primary source of soil organic matter is the decomposition of fine roots rather than the decomposition of surface organics (Powers et al. 2004). Nutrients associated with this material would slowly become available for plant growth. This process would continue until another major disturbance such as fire consumes or partially consumes the accumulated litter, duff, and woody material.

Long-term effects on soil health and productivity are likely to be relatively small from future fires that are within the historic range of variability (Brown et al. 2001). Fire severity exceeding the historic range could have detrimental effects on soil productivity and health through the oxidation and loss of soil organic matter and associated soil biota, as well as through accelerated rates of erosion (Harvey et al. 1987; Harvey et al. 1988; Hungerford 1995).

Following the fires in 2000, Brown et al. (2001) recommended “optimal levels” of 5-15 tons/acre of coarse wood for warm, dry ponderosa pine and Douglas-fir habitat types, and 10 to 25 tons/acre for cool, dry to moist Douglas-fir and for cool lodgepole pine and lower

elevation subalpine fir habitat types in burned areas. Optimal levels account for the historic range of variability in fuel loadings, fire responses to these loadings and to climatic factors in the past few hundred years of the pre-settlement period, as well as considering the risks to resources and firefighters. Brown et al. (2001) coarse woody material recommendations agree with those of Graham et al. (1994) and Harvey et al. (1981) for unburned Rocky Mountain forests.

Nutrient Cycling

Microorganisms would continue to populate the soils, contributing towards site productivity through nutrient cycling and development of soil structure aggregates in areas of poorly developed mineral soils. The occurrence of severe wildfire may alter soil microbial communities by super heating mineral soils and consuming organic matter necessary for microorganism functions.

Soil Disturbance

The No Action Alternative would not lead to direct DSD in the project area.

Indirect Effects

Current vegetative conditions across portions of the project area are at risk for severe wildfire. Not treating at risk vegetative stands may indirectly reduce soil productivity in the event of high severity wildfire.

Cumulative Effects

Alternative 1 would not add to cumulative soil effects unless fires outside of the normal range of variability occur. There would be no additional DSD since management activities would not occur. Noxious weed populations would persist except where currently authorized treatments reduce them.

Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

Alternative 1 meets Region 1 SQS, and manual and Forest Plan direction.

Summary of Effects

The No Action Alternative would not alter the current soil conditions and would not lead to direct DSD in the project area. Soil productivity may be indirectly affected in the event of high severity wildfire in dense stands with heavy fuel accumulations.

3.6.5.3 Direct and Indirect Effects Common to All Action Alternatives

The effects on soils are discussed in terms of the magnitude, duration, and extent of change on soil productivity including soil erosion, mass movement, organic matter (groundcover, coarse woody material, and nutrient cycling), and soil disturbance. Soil disturbance evaluations look at physical changes that may affect productivity. Examples of soil disturbance include detrimental compaction, displacement, puddling, severe fire, and change in hydrologic function.

Direct and Indirect Effects on Soil Productivity

Soil Erosion and Mass Movement

Forests generally have very low erosion rates unless they are disturbed in a manner that exposes bare soils to the erosive energy of water. Management caused disturbances include prescribed fire, harvesting, and post-harvest operations. Soil erosion in harvest

units is diminished by minimizing the amount of bare soils created by disturbance (Clayton and Megahan 1997; Robichaud et al. 2000). The practices that maintain soil productivity (such as leaving organic material on the soil surface, reducing the area impacted by skid trails, and maintaining the hydrologic function) all reduce the risk of soil erosion (FSH 2509.22). In addition, implementing specific erosion control measures such as water bars, placing slash on bare soils, and vegetating disturbed soils conserve the soil resource (Table 2.2-5). The high coarse fragment content of soils in the Como project area provides armoring against erosion.

Risk of mass movement from prescribed fire is also very low. Prescribed fire is typically completed when soil moisture is high (greater than 80 percent) and weather conditions are cool and humid. Intense heating of the soil and complete consumption of organic soil horizons typically does not occur except in select cases where a log or accumulated fuel pile burns for an extended period. The probability of these small areas of disturbance altering slope stability is very low. It should also be noted that mature trees are typically not affected during prescribed burning. The rooting systems of these mature trees would remain intact to provide surface stability.

Organic Matter, Groundcover, and Coarse Woody Material

The action alternatives are designed to leave a variety of organic matter on the site. The practice of leaving organic matter on site provides for microbial populations, which help maintain site productivity (Harvey et al. 1994). Vegetation and organic matter protects the soil surface from raindrop impact, dissipates energy of overland flow, binds soil particles together, and dampens soil temperature extremes and daily fluxes. Studies have found that 60 percent effective ground cover reduced sediment movement substantially and 30 percent ground cover reduced erosion by half compared to bare soil (Robichaud et al. 2000). Logging slash will add to effective ground cover until fine logging slash decomposes over several decades (Clayton 1981).

Any increase in groundcover and/or fine logging slash through harvest may be offset by fuel treatments. Fuels treatments may reduce the amount of organic matter and groundcover in the short-term (0-5 years after treatment) through the use of prescribe fire. In the long-term (greater than 5 years), re-growth of vegetation and annual needle drop would provide groundcover and leaf and litter material necessary for soil organic matter development.

Displacement moves the forest floor and top soil from one place to another. In the absence of fire or erosion, the displaced material is not lost from the site. Page-Dumroese et al. (2000) reports that productivity losses from displacement (while initially high in localized areas less than 100 square feet) may not be significant to site sustainability when compared to large-scale losses from fire or erosion. Powers et al. (2004) noted that complete organic matter removal on long-term soil monitoring plots across the nation had no impact on total vegetative production at 10 years. Research of terraced units on the Bitterroot NF indicates that organic matter and productivity of tree growth are not affected by soil disturbances caused during the construction of terrace benches (Cerise et al. 2013). The construction of these benches was similar to road construction on steep slopes.

Summer Ground Based Harvest Effects

Summer ground-based harvest will reduce ground cover on heavily used landings, areas near landings, and skid trails. An estimated reduction of ground cover up to 10 percent in the proposed ground based units has been used for soil disturbance analysis in this project. Old skid trails remaining from past timber management operations are present in some of the ground based units. These old trails have naturally rehabilitated and do not currently have detrimental soil conditions. These old trails are difficult to locate in many areas. In order to minimize disturbance to soils that have never been ground based yarded, the old trails that are easily identifiable will be reused to the extent feasible.

The main soil concern for ground based yarding in the project area is displacement of thin organic and topsoil horizons. On lightly used trails (one or two passes) ground cover is not anticipated to be reduced along the entire trail length. Compaction of mineral soils may occur but is likely to be buffered by the high percentage of coarse fragments in the soils. Constructing water bars, creating brush sediment traps, or seeding or planting forbs, grasses, or shrubs, will hasten groundcover recovery and reduce soil erosion and movement of soil off-site (FSH 2509.22). Disturbed vegetation would re-grow in less than 5 years except where there is root kill.

Skyline Harvest Effects

Groundcover in skyline corridors would be reduced approximately 5-10 percent as a result of choker setting, cables, and removing logs from the site (Clayton 1981; Klock 1975). In many cases, the displaced groundcover along the corridor occurs in small patches. These small areas (less than 100 square feet) of displacement are not considered DSD. Ground cover reduction would only occur along the corridor where log suspension is limited and numerous yarding passes occur. There would be additional reduction in groundcover due to equipment operations and corridor convergence at the upper segment of the corridor near the yarder.

Loss of groundcover in the corridors will be lessened through partial suspension of logs during yarding and ceasing of operations if wet conditions are encountered. Corridors will have erosion control treatments following logging and site prep activities. The timber sale contract includes treatments such as water bar construction and slash placement on bare soils in the corridors and landings where deemed necessary by the timber sale administrator. In the long-term, (greater than 5 years), we anticipate that groundcover would become re-established in areas of displaced soils, with or without post-activity rehabilitation. Groundcover recovery would be achieved with needle cast and vegetation re-growth.

Coarse Woody Debris

All harvest prescriptions would leave a portion of the existing stand on the site. Yarding will be either whole tree or leave tops attached. Coarse woody debris (material greater than 3 inches in diameter) will be available from designated leave trees, both standing and down, and from breakage of limbs and broken tops that will occur during harvest. However, by leaving larger sized, faster growing trees that will eventually die, becoming snags and then down coarse woody material, the treatments are designed to provide future coarse wood greater than 15 inches in diameter. Large coarse wood persists for longer durations and provides greater benefits to soil development than smaller coarse wood. Large coarse wood is also much less of a concern for fire management. Following

the treatments, the stands will be capable of producing large coarse wood at a faster rate for soil development than current conditions. Currently, in many of the commercial thinning stands, tree diameter at breast height (dbh) is less than 15 inches (especially in lodgepole pine stands); therefore, wood smaller than this will be required to meet coarse wood guidelines developed for this project. To the extent feasible, the largest coarse wood (snags or logs) will be left on-site to satisfy coarse woody material requirements for each treatment unit. Silvicultural prescriptions will account for additional trees that will be required for future coarse wood recruitment in the thinned stands.

The amounts of coarse wood listed in Table 3.6- 3 for each Fire Group will maintain future soil productivity. Additional information concerning coarse woody material is outlined in PF-SOILS-005.

Table 3.6- 3: Coarse Woody Debris (CWD) Requirements as Defined by Graham 1987 and Brown 2001.

FIRE GROUP	CWD
2 and/or **4** = Warm, Dry Ponderosa Pine and Douglas-fir Habitat Types	5 to 10 tons/acre
5, 6 = Cool, Dry and Moist Douglas-fir Habitat Types	10 to 20 tons/acre
7, 8, and/or **9** = Cool Lodgepole Pine and Lower Subalpine Fir Habitat Types	8 to 24 tons/acre

The proposed commercial and non-commercial thinning treatments are anticipated to leave slash on the ground through the winter and into late summer/fall before prescribed burning will be implemented. This will provide opportunity for the nutrients in the slash to be leached into the soil.

Nutrient Cycling

Nearly all units proposed for harvesting will include whole tree yarding or leaving tops attached. Regarding effects of whole tree harvesting on the growth of trees, Wells and Jorgensen (1979) believe that as long as rotations are long, the depletion of the major nutrients needed by plants should not be excessive in relation to total reserves in the soil and that the reserves would be replenished between cuttings. However, they also recognize that plant growth is dependent on the amount of nutrients actually available to the plants and that this available pool of nutrients can be in short supply under some circumstances.

Wells and Jorgensen (1979) reviewed literature about nutrient pools and cycling in forest ecosystems. Their publication indicates that most of the total nutrient content occurs in the mineral soil. The majority of stands examined had 8 to 10 times nitrogen in soil reserves compared to the amount in the trees. Nitrogen is typically the most limiting plant nutrient in forested ecosystems. The main sources of nitrogen replenishment to the soil reserves are through mineralization of organic matter, atmospheric inputs, and nitrogen fixation by soil organisms. Jurgensen et al. (1981) 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.

Phosphorus is a nutrient (macronutrient) critical for plant growth and is often only slowly available to plants. Its main sources are the weathering of soil minerals such as apatite and through organic matter decomposition. The phosphorus removal rate through timber

harvest is usually less than it is for nitrogen because an even larger proportion of total site phosphorus occurs in the soil than in above ground biomass. Morrison and Foster (1979) cite the disparity in nutrient distribution between above and below ground biomass in a *Pinus banksiana* forest growing in sandy glacio-fluvial soil in Ontario. The percentage of total site nitrogen was 95 percent in the soil reserves and 5 percent in the tree canopy; for phosphorus 99 percent of total site phosphorus occurred in the soil whereas, only one percent was found in the tree canopy.

The status of other nutrients is unknown although there are no site indicators which would point to a problem with nutrient availability or cycling in the units. Removal of potassium in whole tree harvests is modest in comparison to soil reserves according to Wells and Jorgensen (1979). Tree growth and ground cover is within the range expected for the site conditions.

Page-Dumroese (2000) found that relatively small levels of disturbance (less than 15 percent of the area) resulted in relatively small losses in carbon, nitrogen, and cation exchange capacity (CEC), ranging between 1 to 13 percent of the available pools. She concludes that at these levels of loss, current soil quality guidelines appear to be adequate. It must be noted that this is based on initial research from the Long-term Site Productivity Project (LTSP) and results may change as more data accumulates in the future.

Fire suppression in ponderosa pine has resulted in a build-up of forest litter and accumulation of organic matter (DeLuca 2000). DeLuca's research shows the positive benefits of reducing fuel loading and renewing the growth of desirable understory plants through the use of fire or harvest or a combination of both. Ponderosa pine communities commonly accumulate little inorganic nitrogen in mineral soil because of the slow decay rates and rapid uptake by plants and microorganisms. In addition, limited quantities of nitrogen may be available due to the accumulation of organic matter composed of woody residue, naturally low in nitrogen. Wildfire and prescribed fire release plant available nitrogen, however a first entry of high severity wildfire may result in root kill and overall reduction in nitrogen mineralization potential.

DeLuca (2000) found prescribed fire following selection or shelter wood harvest provided a short-term increase in mineral nitrogen followed by a long-term decline in available nitrogen. This may seem like a negative impact of fire reintroduction; however, the reduced stand density has a lower nitrogen demand. In addition, the Nitrogen/Potassium ratio would be in better balance and improve the trees resistance to disease and insects.

Retaining limbs and branches on site over the winter provides for nutrient leaching into the soil (Palviainen et al. 2004; Baker et al. 1989). Baker et al. 1989 found that there was little leaching of nutrients from live or dried needles immediately after harvest. However, after 3 months of decomposition he noted appreciable nutrient releases. Some of these nutrients may not be available to the remaining stands as organisms in the forest floor use them during decomposition. Researchers conclude that logging slash acts as a nutrient sink (Barber and Van Lear 1984).

To summarize, by maintaining organic matter and ground cover on at least 85 percent of the site, as prescribed in the action alternatives nutrient cycling and availability will not be altered. The design features (Chapter 2) and Region 1 soil quality guidelines are

prescribed to achieve this desired outcome. Localized losses may occur at landings or where severe fire occurs.

Direct and Indirect Effects to Soil Disturbance

Summer Ground-Based Harvest, Units or Portions of Units

Summer ground-based harvest is proposed for all Action Alternatives. Areas of reduced soil productivity from ground based yarding include temporary roads, skid trails, excavated skid trails, and landings. Design features (Table 2.2-5) and Montana BMPs and SWCPs are prescribed to limit the severity of any soil damage or its areal extent. Table 3.6- 4 displays a summary of ground-based harvest and potential acres of DSD for each alternative.

Table 3.6- 4: Summary of Ground-Based Activities and Potential DSD for the Action Alternatives.

ALTERNATIVE	GROUND-BASED HARVEST UNITS (#)	GROUND-BASED HARVEST (ACRE)	POTENTIAL DSD (%)	POTENTIAL DSD (ACRE)
2	25	909	10	91
3	22	941	10	94
4	23	909	10	91

The DSD estimates for the action alternatives are conservative calculations. Actual detrimental soil conditions are anticipated to be less due to the high coarse fragment content soils. The high percentage of coarse fragments will minimize compaction during ground-based activities. Displacement and loss of organic and topsoil horizons is of greater concern in these coarse textured soils. Individual unit analysis is included in Table 3.6- 10 - Table 3.6- 12.

In order to further protect soils, ground based yarding in this project will occur when soils are dry (soil moisture is near or below the permanent wilting point). During the summer, drying of the soil profile increases the soil density and strength reducing equipment impacts. This densification occurs even on undisturbed soils due to surface sealing. The dry soil conditions will limit displacement and mixing of organic horizons.

Research conducted during dry season operations (summer) have documented increases in ground disturbance of 5 to over 40 percent, depending on equipment used and method of operation. Typically, soil disturbance is found on less than 15 percent of the activity unit (McNeel et al. 1992; Seixas 1995; McIver and Starr 2000; Clayton 1990; Watt and Krag 1985, Klock 1975). Disturbance is generally limited to main skid trails and landings due to higher traffic. Recent monitoring of summer ground-based harvest on the Bitterroot NF indicates that DSD ranges from 0 to 10 percent, typically averages five percent (Forest Monitoring Reports 2002-2005 (PF-SOILS-007)). Soil quality monitoring (Summer 2006) on three different sales indicated that summer ground based harvest added 0 to 4 percent DSD (2006 - BNF Forest Soil Quality Monitoring (PF-SOILS-007)). Bitterroot NF monitoring data is used to calculate DSD in this project. Soils analysis in this project uses a conservative 10 percent DSD estimate – the high end of the range noted for summer ground based harvest during recent soil quality monitoring on the Bitterroot NF.

Research out of Canada suggests that coarse textured soils with low clay contents may resist compaction because aeration pores result from packing together mineral grains

(British Columbia Canada 2002). Gomez et al. (2002) found that on sandy soils severe compaction actually increased water holding capacity. The severe compaction was found to increase the number of days that water was available for uptake from 45 days to 131 days. The water holding capacity was increased in the sandy loam soils by altering the soil physical structure to create more fine pores for water storage. The majority of the project area is comprised of coarse textured soils (primarily sandy loams derived from quartzite) with less than 15 percent clay. However, as previously mentioned, compaction will be limited by the high amount of coarse fragments which will support the weight of the ground based equipment and prevent soil particle compression.

Skyline and Track-line Machine Yarding

Skyline and track-line machine yarding is proposed in Alternatives 2 and 4. Skyline machine yarding is proposed in Alternative 3 but no track-line machine would be used. Areas of reduced soil productivity from skyline and track-line machine yarding include skyline corridors and track-line machine trails. Design criteria and SWCPs are prescribed to limit the severity of soil damage or its areal extent. Table 3.6- 5 provides a summary of DSD estimated for each skyline unit.

Table 3.6- 5: Summary of Conventional Skyline Yarding and Track Line Machine Yarding and Potential DSD for the Action Alternatives.

ALTERNATIVE	(# OF UNITS)	CONVENTIONAL SKYLINE (ACRE)	TLM (ACRE)	POTENTIAL DSD (%)	POTENTIAL DSD (ACRES)
2	15	87	92	4	7
3	6	70	0	4	3
4	5	31	10	4	2

Soil disturbance occurs during skyline yarding when moving trees to and within skyline corridors. These corridors are narrower than skid trails created by ground-based equipment. Skyline corridor spacing typically averages 100 feet. In this situation, corridors comprise approximately 3% of a unit. Soil disturbance from skyline logging may be greatest at the landing where logs have limited suspension and corridors converge. Ensuring good suspension of the log and avoiding wet soil conditions will minimize soil disturbance. Design criteria for summer skyline yarding include construction of waterbars in corridors where yarding has exposed mineral soils (included in timber sale contract clauses) and seeding areas of bare soil within the corridors and placing slash where the timber sale administrator identifies the need in order to minimize the risks of soil erosion.

Research and monitoring has shown that summer skyline logging typically causes from 3 to 10 percent detrimental soil damage (McIver 1998, Clayton 1981, McIver and Starr 2001). Monitoring following salvage logging in the Bitterroot NF after the fires in 2000, showed summer skyline yarding causes little detrimental soil disturbance (Forest Plan Monitoring Reports 2002-2009 (PF-SOILS-007). In addition, the monitoring found mitigation measures employed in the corridors were effective at limiting offsite erosion (no erosion, rill or gully formation in the corridors was noted). Loss of organic matter and ground cover was minimal (BAR timber sale unit logs, 2001-2004). Monitoring of skyline sales on the Bitterroot NF indicates that DSD does not occur in the absence of tractor swing or track-line machine trails (Forest Plan Monitoring Reports 2002-2009 (PF-SOILS-007).

Track-line machine yarding is completed in a manner similar to conventional skyline yarding with the exception that logs are skidded from the track-line machine to the nearest road to load logging trucks. In contrast, conventional skyline typically occurs directly off of an existing road system. Track-line machine yarding has higher detrimental disturbance than conventional skyline yarding because the impact of constructing the trail required to skid logs is similar to constructing a temporary road. These constructed trails resemble temporary roads but are not designed to accommodate logging trucks. Typically, track-line machine yarding detrimentally disturbs 2 to 9 percent of a unit, primarily due to the construction of the trail.

It may not always be necessary to construct a track-line machine trail if the topography allows for safe travel of the track-line machine itself and the skidding equipment. In cases where no trail is constructed, there would be small landing sites (up to 1/10 acre in size) where the track-line machine levels a small pad and yards logs into a small deck. In most cases, a trail is constructed and the track-line machine sits on the trail and decks logs on the trail for skidding to the road system. The analysis for the Como FEIS assumes that all track-line machine units will have constructed trail. All log decking and skidding of volume/trees from track-line machine units will occur on the constructed trails in order to minimize soil disturbance. Similar to temporary roads, all track-line machine trails will be obliterated and rehabilitated upon completion of harvest activities.

Post-Harvest and Fuel Reduction Activities

Harvest generated slash treatment and fuel reduction would be completed on commercial and non-commercial thinning units. In some cases, only part of the unit requires slash treatment. Options for treatment include jackpot burning, underburning, lop and scatter, hand piling or a combination of these treatments.

Duration of Harvest Effects

The main concern for loss of soil productivity in the project area is the displacement of thin organic and topsoil horizons during ground-based operations and in skyline corridors. Long-term recovery of surface organic and topsoil to current conditions should occur within 30 to 40 years. This time frame is based on the observations of past skid trails in the activity units. Past skidding operations occurred in the 1970s and early 1980s. The trails are still evident, but observations during field surveys indicate that surface soil conditions on the skid trails are similar to adjacent undisturbed areas.

Short-term recovery of surface horizons can be expected within 5 years in most areas. The short-term timeline for surface organic matter recovery is based on monitoring observations of burned units on the Lil Lyman Salvage and Reforestation Project. Monitoring of these units was completed 3 to 5 years following the fires in 2000. Surface organic horizon (surface litter and duff) depth was measured at approximately 1 to 1.5 inches. Ground cover (large rock, duff, surface litter, and plant cover) averaged greater than 60 percent except in Units 5 and 4 where the fire was more severe. Prior to the fires, organic matter in the top six inches of soil averaged 3 to 5 percent of the soil volume with a duff depth of 1 to 3 inches.

In addition to project monitoring, research from the Sleeping Child burn found herbaceous cover to increase up to five percent a year for the first 2 years (Lyons 1976 and 1984). Lyons (1976, 1984) further found herbaceous plant cover increased

approximately 15 percent by year 3, 20 to 25 percent by year 6, and 60 percent by year 10.

Though recovery timelines for both physical soil properties and organic matter with humus and topsoil formation are long; the Como Forest Health project will not change the natural recovery processes. Vegetation, organic matter, and ground cover will be preserved on all but the landings and heavily used skid trails. Soil disturbance will be limited to the extent feasible through implementation of BMPs, SWCPs, and design features. This project will not result in irreversible changes to soil structure or organic matter over time.

Further discussion on duration of harvest effects to soils is included in the cumulative effects section.

Maintenance Burning and Prescribed Fire

The effects of this treatment would be similar to a low severity wildland fire that reduces fuels while preserving most of the live trees, shrubs, and other forest vegetation. Underburning, broadcast burns, or other forms of prescribed fire are proposed on most of the treatment areas in the Action Alternatives. Burning in spring or fall would reduce effects caused by high soil heating such as loss of nutrients through volatilization (Neary et al. 1999). Soil organisms necessary to recycle nutrients would be available on the burned sites. Ideal soil conditions for maintenance and prescribed burns typically occur in the spring or fall.

Bacteria (Nitrosomas bacteria) and fungi are relatively sensitive to the increased soil temperatures encountered with light to moderate severity fire whereas sulfur, soil structure, soil wettability, nitrogen, and organic matter are only moderately sensitive (Neary et al. 1999). The risks to soil organisms lowers when soil moisture content is low (less than 15 percent) and the duration of the heat is less than 30 minutes. Conversely, the potential for nitrogen loss and infiltration loss increases in dry soils.

Upon completion of maintenance burning or other prescribed fire activities, at least 70 percent ground cover is necessary to prevent detrimental accelerated erosion and loss in soil productivity. Mitigation for this project will assure that in those cases where ground cover is less than 70 percent prior to burning, consumption and loss of ground cover should not exceed 15 percent. Ground cover includes duff, organic soil horizons, basal area of vegetation, fine woody material, coarse woody material, and surface coarse fragments. Fire prescriptions will be designed to meet these soil protection requirements (Fire and Fuels Section).

Coarse woody debris (CWD) requirements must also be considered where prescribed fire is used. Design criteria will assure that prescribe fire operations will attempt to minimize the loss of CWD needed for soil development. In fuel reduction project areas where CWD is nearing the low threshold levels, care will be taken to not intentionally ignite CWD during hand lighting operations. Prescribe fire can be used in these areas to recruit additional CWD through burn mortality. Burning prescriptions will be written and implemented to consider CWD requirements as well as other resource limitations. These treatments would not create DSD and would meet the Region 1 soil quality guidelines for all action alternatives.

Non-Commercial Thinning Units (Lopping and Scattering)

Lopping and scattering of small, un-merchantable material will mitigate the loss of nutrients from whole-tree yarding. This practice will also add small coarse woody material to the site. Slashing of this material may occur on some commercial thinning units. It is therefore anticipated that no major, long-term negative effects will result from the whole tree harvest prescription. The soil scientist field reviewed these proposed activities in the commercial harvest units.

Non-commercial thinning in units will typically involve slashing of trees up to 7 inches DBH. There are some units where slashing of trees up to 10 inches DBH is proposed.

Unit 36 currently has 20% DSD due to displaced topsoil and compaction and is proposed for non-commercial thinning. The slashed material will be left scattered across the unit to provide organic matter for soil recovery. Increased fine and coarse woody debris on the soil surface will increase soil moisture and improve soil biological activity. The woody debris will also accelerate natural soil recovery processes to alleviate compaction. The soil scientist will review the unit with the fuels specialist one year after slashing to determine the need for prescribed fire.

Landing Construction and Use

Landings would be associated with each commercial thinning unit. Frequent, small, roadside landings would be used for the skyline and ground-based operations. These landings would be located on the edge of existing system roads and generally within the road right-of-way. Disturbances associated with roadside landings are typically not considered DSD since these landings are considered part of the forest transportation system (SOILS-001).

In ground-based units where landings are internal to a unit (often adjacent to a temporary road), we estimate that landing size would range between 1/10 to 1/4 acre. Disturbances from proposed landing sites internal to activity areas accessed by a temporary road are included in the calculations for DSD (see tables 3.6-10 through 3.6-12). Necessary erosion controls will be implemented (slashing, waterbars) and revegetation practices will be completed to prohibit invasive plant establishment.

In track-line machine units, a trail will be constructed to accommodate yarding and the skidding of logs to a roadside landing. If no trail is constructed, landing disturbances up to 1/10 acre would be created at the top of each track-line machine corridor. The analysis for the Como FEIS assumes that all track-line machine units will have constructed trail. All log decking and skidding internal to the unit will occur on the constructed trails in order to minimize soil disturbance. Similar to temporary roads, all track-line machine trails will be obliterated and rehabilitated upon completion of harvest activities.

Temporary Road, Track-line Machine Trail, and Excavated Skid Trail Construction and Rehabilitation

Soil disturbance from temporary road, track-line machine trail, and excavated skid trail construction is considered detrimental for the purpose of DSD calculations in this document. Disturbances from these construction activities are considered DSD even after rehabilitation activities; however the detrimental effects will slowly be reduced over time through natural recovery. The detrimental soil conditions from temporary roads may reduce soil productivity for several years until vegetation, organic matter, and hydrologic

functions are restored. Table 3.6- 6 displays the miles of temporary road construction and acres of associated DSD.

Table 3.6- 6: Temporary Road Construction and Detrimental Soil Disturbance for the Action Alternatives.

ALTERNATIVE	TEMPORARY ROADS (FEET)	TRACK-LINE MACHINE TRAILS (FEET)	EXCAVATED SKID TRAILS (FEET)	DSD BASED ON 12FT WIDTH (ACRES)
2	10,442[1]	13,457	537	5.2
3	0	0	0	0
4	6,007[1]	2,660	639	1.8

[1] The number represents the total length of temporary road, 2,800 feet of temporary road would be located on historic road prism.

All temporary roads, track-line machine trails, and excavated skid trails would be rehabilitated as part of the timber sale or stewardship contract. Rehabilitation activities would include recontouring, slashing, fertilizing, and seeding to restore soil productivity to the extent possible. Establishment of vegetation on the rehabilitated areas will be observed by forest personnel the following growing season, any areas with poor establishment will be re-seeded by forest personnel.

Recontouring speeds the process of vegetation and hydrologic recovery, which alleviate detrimental conditions over time. By completing the rehabilitation activities, the detrimental soil conditions are not anticipated to persist nor are they considered a permanent loss in soil productivity.

Alternatives 2 and 4 have proposed temporary road, track-line machine trail, and excavated skid trail construction which would lead to higher direct soil disturbances (7 acres and 1.8 acres DSD, respectively) than Alternative 3 where no construction is proposed. Approximately 2,800 feet of temporary road in Alternative 4 would occur on historic road prism where detrimental soil compaction currently exists. No new disturbance would occur on the historic prism, in the long-term rehabilitation efforts will lead to improved soil productivity on these obliterated historic roads.

Specified Road Construction

Specified road construction is proposed in Alternatives 2 and 4 (9,194 feet and 3,528 feet respectively). These road segments will become part of the dedicated transportation system and would no longer be managed as part of the productive land base. Based on a road clearing limits of 30 feet for specified roads, approximately 6.3 acres will be removed from the productive land base in Alternative 2 and 2.4 acres in Alternative 4. Specified road construction effects to other watershed resources are discussed in the Hydrology section.

Road Decommissioning, Storage, and Closure Treatments

The transportation system within the project area has been reviewed by the interdisciplinary team (ID Team) to determine the future needs for roads. This review included both Forest system roads and undetermined status roads. Table 3.6- 7 includes only current system roads and undetermined status roads that are proposed for decommissioning ,storage, or closure in this project. Further information on all roads in

the project area, current status, and definitions can be found in the Transportation section.

Two roads currently on the transportation system in stored status will be decommissioned (NFSR 62939 and the end segment of NFSR 62945). NFSR 62939 has grown in with vegetation and is not accessible by vehicle. This road is proposed to be decommissioned from the junction with NFSR 62925 to the end of the road (approximately 0.17 miles). No treatment of the road is required due to natural recovery. The entrance will be blocked to prohibit future motorized access. The road is currently used for non-motorized recreation and non-motorized use will continue.

The last 0.16 mile of NFSR 62945 will be decommissioned and new specified road construction is proposed to connect with the remainder of NFSR 62945 to provide access to Unit 50 and the adjoining plantation. The last 0.16 mile of NFSR 62945 will be fully obliterated which will require decompacting and recontouring the road to match existing topography in the area. The road is located in an area with many boulders which will be used in various locations to blend the recontoured road with the existing landscape. Compacted historic skid trails connecting to the end of the road will also be decompacted and rehabilitated with available woody debris. The rehabilitated skid trail and recontoured road would be seeded and fertilized with an organic fertilizer. These decommissioned roads will return to the productive land base.

Table 3.6- 7: Forest System Roads and Undetermined Status Roads that are Proposed for Decommissioning, Storage, or Closure. The treatment required column provides information about the physical activity required to decommission or store the road.

ROUTE ID	CURRENT STATUS SYSTEM OR UNDETERMINED	LENGTH (MILES)	REQUIRED FOR LOG HAULING	PROPOSED STATUS – DECOMMISSION, STORAGE, OR CLOSURE	TREATMENT REQUIRED
13231	Undetermined	1.04	Yes	Store	Block/recontour entrance, scarify roadbed, revegetate
13290	Undetermined	0.41	Yes	Maintain yearlong closure	Improve road surface drainage, maintain administrative access
62925	System	0.21	Yes	No change - store	Block/recontour entrance, scarify roadbed, revegetate
62930	Undetermined	0.41	Yes	Store	Block/recontour entrance, scarify roadbed, revegetate
62931	System	2.14	Yes	Maintain yearlong closure	Improve road surface drainage, maintain administrative access
62932	Undetermined	0.69	Yes	Store	Block/recontour entrance, scarify roadbed, revegetate
62933	System	3.91	Yes	Maintain yearlong closure	Improve road surface drainage, maintain administrative access
62934	Undetermined	0.79	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62935	Undetermined	0.27	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62936	System	0.21	No	Store	Portion of road adjacent to the rock pit will be decompacted to

Route ID	Current Status System or Undetermined	Length (miles)	Required for Log Hauling	Proposed Status – Decommission, Storage, or closure	Treatment Required
					address erosion and stream sedimentation issues. Entrances to the road will be blocked.
62937	System	0.37	Yes	No Change - store	Block/recontour entrance, scarify roadbed (maintain portion for existing non-motorized access), revegetate
62938	System	0.64	Yes	No Change - store	Block/recontour entrance, remove culverts if post haul conditions warrant removal, scarify roadbed (maintain portion for existing non-motorized access), revegetate
62939	System	0.17	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62939	System	0.16	No	Maintain yearlong closure	No treatment
62940	System	0.1	Yes	Maintain yearlong closure	Improve road surface drainage, maintain administrative access
62942	System	0.56	Yes	No Change - store	Block/recontour entrance, scarify roadbed, revegetate
62944	Undetermined	0.51	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62944	Undetermined	0.32	Yes	Storage	Block/recontour entrance, remove culverts if post haul conditions warrant removal, scarify roadbed, revegetate
62945	System	0.16	No	Decommission	Recontour/fully obliterate this end segment of road
62945	System	0.22	Yes	No Change - store	Block/recontour entrance, scarify roadbed, revegetate
62963	System	0.56	Yes	No Change - store	Block/recontour entrance, scarify roadbed (maintain portion for existing non-motorized access), revegetate
62964	Undetermined	0.08	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62965	Undetermined	0.23	Yes	Storage	Block/recontour entrance, scarify roadbed, revegetate
62966	System	0.89	Yes	No Change - store	Block/recontour entrance, remove culverts if post haul conditions warrant removal, scarify roadbed, revegetate

ROUTE ID	CURRENT STATUS SYSTEM OR UNDETERMINED	LENGTH (MILES)	REQUIRED FOR LOG HAULING	PROPOSED STATUS – DECOMMISSION, STORAGE, OR CLOSURE	TREATMENT REQUIRED
62967	Undetermined	0.52	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62968	Undetermined	0.23	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62968A	Undetermined	0.04	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62972	Undetermined	0.23	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62973	Undetermined	0.25	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access
62974	Undetermined	0.58	No	Decommission	Natural recovery – treatment required only to block/recontour entrance to motorized access

*TOTAL SYSTEM ROADS CURRENTLY STORED PROPOSED FOR DECOMMISSIONING	**0.3** MILES
TOTAL SYSTEM ROADS CURRENTLY CLOSED YEARLONG THAT REMAIN ON SYSTEM AND RETURN TO CLOSED YEARLONG AFTER LOG HAULING ACTIVITIES	**6.3** MILES
TOTAL SYSTEM ROADS CURRENTLY CLOSED YEARLONG THAT WILL BE TREATED AND PLACED IN LONG TERM STORAGE	**3.7** MILES
TOTAL UNDETERMINED ROADS THAT WILL BE CONVERTED TO SYSTEM ROADS CLOSED YEARLONG TO MOTORIZED TRAVEL	**0.4** MILES
TOTAL UNDETERMINED ROADS THAT WILL BE CONVERTED TO SYSTEM ROADS IN STORED CONDITION AFTER LOG HAULING ACTIVITIES	**2.7** MILES
TOTAL UNDETERMINED ROADS THAT WILL BE DECOMMISSIONED AFTER LOG HAULING ACTIVITIES	**3.5** MILES

A total of 10.3 miles of currently stored system roads are shown in Table 3.6- 7 will be re-opened for commercial thinning activities. These re-opened roads are proposed for log hauling and will need to be cleared of vegetation and the road surface improved to accommodate log truck traffic. The majority of these roads will be placed back into storage upon completion of log hauling. The storage treatment will involve scarifying the road surface (scarification less than 6 inches in depth), seeding, and fertilizing. Revegetation efforts will provide ground cover to re-stabilize the road surface. The entrances of these roads will be physically blocked with a gate, rock barrier, or the first 50 to 100 feet recontoured to prohibit motorized access. Stored roads that are currently used for non-motorized recreation (NFSR 62937, 62938, and 62963) will be scarified in a manner that accommodates continued non-motorized recreation.

The ID Team determined approximately 3.5 miles of undetermined status roads were not necessary for forest management or recreation uses and proposed they be decommissioned. These roads have naturally recovered and are grown in with trees. No treatments will be required on the ground to decommission the roads. The entrances of these roads may be blocked or recontoured if potential for future motorized access is a concern following thinning activities.

The ID Team likewise identified about 3.1 miles of undetermined status roads as necessary for forest management and proposed they become part of the transportation system. These roads would be opened to accommodate commercial thinning operations including log hauling. Vegetation would be cleared and the road surface improved. Upon completion of thinning activities, these roads would be closed (0.4 miles) or stored (2.7 miles). Road closure will involve blocking the road entrance with a gate or earthen mound. Road storage will involve scarifying the road surface (scarification less than 6 inches in depth), seeding, and fertilizing. The entrances of these roads would be physically blocked with a gate, rock barrier, or the first 50 to 100 feet recontoured to prohibit motorized access.

Summary of Direct and Indirect Effects by Treatment Unit

Direct effects to soils within proposed treatment units are summarized in Table 3.6- 10 to Table 3.6- 12 for the Action Alternatives. The tables display existing DSD levels, DSD from proposed management activities, and cumulative DSD for individual treatment units. The tables include only those proposed forest management activities that will result in new DSD (commercial thinning, temporary roads, track-line machine trails, excavated skid trails, and landings). The analysis of DSD in the table does not account for rehabilitation of temporary roads, track-line machine trails, and excavated skid trails.

Design Features Common to All Action Alternatives

The proposed treatment units include design features to minimize losses in soil productivity or increases in soil disturbance. Furthermore, this effects analysis assumes that State of Montana Best Management Practices (BMPs), Region 1 Soil and Water Conservation Practices (SWCPs) Handbook 2509.22, and Forest Standards and Regional Guidelines will be implemented and be effective. Soil technical support has been provided for all project alternatives throughout project design and planning.

Design features to protect the soil resource are summarized in Table 2.2-5. All other soil protection measures are covered by SWCPs and BMPs.

Design features effectively minimize soil disturbance. For example, Han-Sup et al. (2005) found logging during dry months reduces compaction on fine textured soils since soil strength is maximized when soil moistures are less than 10 to 15 percent (below field capacity). Harvesting when soils are dry also limits the machinery impact on the wheel track. Above this moisture content, soils are more prone to compaction with the extent of compaction being greater in width and depth.

Forestry practices on the Bitterroot National Forest are required to follow State of Montana BMPs. The State of Montana monitors these practices every two years, the last one was conducted in the summer of 2012 (State of Montana 2012). The audit in 2012 found that across all ownerships, BMPs were properly applied 98 percent of the time and overall effectiveness of the implementation was 98 percent.

3.6.5.4 Cumulative Effects of the Alternatives

Cumulative effects section discloses the combined, incremental effects of human activities. For activities to be considered cumulative, their effects need to overlap in both time and space with those of the proposed actions. For the soil resource, the area of consideration is the harvest unit since effects on soil effects are site specific. Soil erosion (including mass failure) is an exception. Soil erosion is discussed in the Hydrology cumulative effects section.

Existing Conditions and Past Activities

Legacy soil disturbance (disturbance that occurred as a result of past activities) forms the foundation of the soil conditions on the landscape today, the existing soil condition. These activities include but are not limited to: timber harvest, grazing, road construction, recreation, restoration, and fires.

For past, present, or future activities to overlap in time, the effects on soils from the activities must overlap. Soil physical changes (detrimental compaction, detrimental displacement, detrimental erosion, severe burning, and puddling) can persist in the landscape for greater than 20-40 years following management activities. Biological soil conditions change quicker, for example re-vegetation occurs within 5 years (under most situations) and organic matter begins to rebuild in 10 years but may take greater than 50 years to reform humus. Time discussions will look back to at least the 1970s, which cover both the physical and biological aspects of the soil.

Cumulative Effects of Harvest at the Project Scale

Approximately 3,880 acres or 68 percent of the project area has been harvested since the early 1900s (FACTS database). Activities that have the most impacts on soils, such as timber harvest and mechanical site preparation, are compiled from the database and displayed in Table 3.6- 8.

The combined area of past harvest activities displayed in Table 3.6- 8 totals approximately 3,880 acres in the project area. Activities have occurred on the same acres in some cases. For example, some shelterwood harvests have been followed by clearcut harvests; therefore, the actual area affected by these past activities would be less than 3,880 acres.

Harvest activities that have created long term (>50 years) DSD are primarily the result of past ground-based yarding. Yarding practices prior the late 1980s often did not adhere to soil protection measures such as operating on dry soils or designated skid trails. Timber was removed from the forest as economically as possible. Soils were compacted and displaced by skidding. Displacement of mineral soil during harvest prior to the late 1980s was often considered desirable because trees regenerated well on these sites due to reduction in competition from surrounding vegetation.

Soils in previously disturbed areas are recovering based on recent field surveys of treatment units. Previously displaced soils have redeveloped organic horizons and are recovering productive topsoil horizons in most areas. Some areas, heavily disturbed in the past (such as old landings, burn piles, and major skid trails) have minimal organic horizon recovery, leaving mineral soils exposed to erosion and weed colonization. Sandy loam to loam textured soils dominate soil types across the project area. Compaction in these soil textures from past harvest have improved naturally in the surface horizons (approximately 0 to 6 inches). In some cases, subsurface compaction persists through 6 to 12 inches of

the soil profile. Natural recovery will continue over time through freeze/thaw cycles and root penetration. Approximately 30% of historic skid trails were determined to have root limiting compaction considered to be detrimental to soil function. This information is based on soil monitoring during recent field surveys.

Table 3.6- 8: Cumulative Harvest Activities in the Project Area.

TIMEFRAME	*HARVEST TYPE/PRESCRIPTIONS - ACRES						
	CLEAR-CUT	SALVAGE/ SANITATION	SHELTER WOOD	LIBERATION	SINGLE-TREE SELECTION	GROUP SELECTION	COMMERCIAL THIN
1900 - 1950	146		141				
1950s				117			
1960s			66	515	726		
1970s		167	40	145	20	61	
1980s	146	202		278	98		
1990s		196	77		299	3	295
2000s							72
2010s							70
TOTAL	**292**	**565**	**324**	**1,055**	**1,143**	**64**	**437**

*Harvest Type/Prescriptions are described in the Silviculture section.

Cumulative Effects of Forest Management at the Treatment Unit Scale

Cumulative activities that have occurred within treatment units are discussed in the following section. The harvest designs and mitigations proposed for treatments have been developed from the field review of disturbances from past activities.

Past Harvest and Post-Harvest Activity Effects

Past harvest/thinning activities have occurred in the proposed treatment units. The majority of these units have had entries since 1960. Past vegetation management has involved a wide variety of treatments including clear-cutting, shelterwood harvest, and salvage & sanitation treatments (Table 3.6- 8).

Past harvest consisted of a mixture of ground-based and skyline yarding similar to the proposed project. Ground based yarding was noted on continuous slopes exceeding 35%, which would not occur during today's logging practices. Machine piling of slash and mechanical site preparation was a common practice prior to the mid-1980s and occurred in the project area (Meurisse 1987).

Past ground-based operations often gave little thought to skid trail layout. In 1981, Froehlich showed that designating skid trail locations greatly decreased the areal extent of soil disturbance. When skid trails were established at 100 foot spacing, 11 percent of a unit would be covered in skid trails (Froehlich 1981). By the mid to late 1980s, forest practices were changing to incorporate these findings. For example, skid trails were designated, season of use considered, and the practice of machine piling slash was limited. These and other BMPs, SWCPs, and Forest Plan Standards and Guidelines were developed using this research to manage timber harvest yet sustain site and soil productivity.

In the current era of resource management and harvesting practices, additional emphasis is given to the season of harvest, ensuring that equipment operations are limited to

designated areas, and that post-harvest activity does not reduce site and soil productivity. Conservation of soil organic matter and coarse woody material are considered in every project. Skid trails used in current harvest operations are rehabilitated with waterbars, slash placement, ripping or subsoiling, and/or planting shrubs or sowing grass seed to speed natural recovery and keep nutrients and soil on site.

The Bitterroot NF has ended the practice of dozer-piling slash, opting for selective grapple-piling using low ground pressure equipment or whole tree yarding. This combination of equipment requires repeated trips on closely spaced skid trails due to the limitations of boom-reach with the feller-buncher. The use of low ground-pressure FMC torsion-bar suspension skidders lessens these detrimental soil impacts substantially (Froehlich 1978).

Invasive Plants

Small populations of spotted knapweed have invaded portions of the planning area, primarily along road systems (See Invasive Plants Section). The site-specific effects of these invasions on soil productivity is not known, however, research has shown soil productivity alteration to be minimal where the invasive plants are interspersed with native plants (LeJeune and Seastedt 2001; Hawkes et al. 2005). Where invasive plants form a monoculture, soil productivity in the form of carbon to nitrogen ratios, nitrogen to phosphorus ratios, and soil organism and mycorrhizae communities may be altered (LeJeune and Seastedt 2001; Hawkes et al. 2005).

Coarse Woody Debris (CWD)

The CWD requirements for this project are discussed in Direct and Indirect Effects for All Action Alternatives and are displayed in Table 3.6-3. The CWD requirements for this project are based on the most current science, which differs from the amounts shown in the Forest Plan (PF-SOILS-005). A forest plan amendment has been developed to address the CWD issue. The amended CWD requirements for this project will encompass less than 0.1 percent of the Bitterroot NF (based on maximum treatment area of 2,243 acres in Alternative 3). Since the 1987 Forest Plan, a number forest plan amendments have been needed to ensure CWD retention in fuel reduction treatments were based on current science. These amendments in combination with Alternative 3 of this project (maximum treatment area) cumulatively amount to approximately 1.5 percent of the Bitterroot NF. The modifications of the CWD requirements for this project will not have appreciable cumulative effects at the site or forest scale.

Cumulatively, by implementing this site-specific standard for CWD and snags, the area is expected to have appropriate levels of CWD by fire group over time, fully supporting Forest Plan goals and objectives. There is no perceptible cumulative effect of this amendment in conjunction with the thermal cover and visual quality objective Forest Plan amendments.

Other Activities

Grazing overlaps the proposed treatment units. Soil disturbance from grazing is limited to areas where the animals bed, lounge, trail, or access water. These areas are generally small in areal extent. Soil disturbances include compaction, removal of groundcover, and displacement.

Dispersed camps are located along the roads and adjacent to or on the edge of harvest units. Illegal off-road vehicle use has occurred within the project area, primarily as

connectors between roads. These illegal trails will be rehabilitated by decompacting, placing woody debris, seeding, and fertilizing.

Other activities such as road maintenance, firewood collection, and other past projects have occurred outside unit boundaries and are discussed under the hydrology cumulative effects analysis. Wild fires are always a possibility and may overlap with the proposed treatment units.

Cumulative Effects from the Implementation of the Proposed Action Alternatives at the Treatment Unit Scale

Table 3.6- 9 displays a summary of the cumulative effects by alternative. Table 3.6- 10 - Table 3.6- 12 provide the cumulative DSD for individual treatment units following implementation. No treatment units have cumulative amounts of DSD that exceed R1 SQS.

Table 3.6- 9 Summary of Cumulative Soil Effects by Alternative. Analysis is Based on Summary of DSD within Treatment Units

DETRIMENTAL SOIL DISTURBANCE (DSD)	ALT 1 – EXISTING CONDITION	ALT 2	ALT 3	ALT 4
EXISTING DSD (ACRES)	93	93	93	93
DSD FROM PROPOSED TREATMENTS (ACRES)	0	122	111	106
CUMULATIVE DSD (ACRES)	93	172	161	155

*Note that DSD from proposed treatments plus existing DSD does not add up to the cumulative DSD for the Action Alternatives. The cumulative DSD considers that 50% of the historic skid trails with existing DSD will be reused, which minimizes the amount of new soil disturbance created during yarding operations.

Based upon field surveys, there are approximately 93 acres of detrimentally disturbed soils located within treatment units in the project area. The majority of the DSD is the result of past skidding operations.

All Action Alternatives would lead to additional detrimental soil conditions from yarding operations, landing sites, excavated skid trails, and the construction of track-line machine trails and temporary roads. Note that DSD from proposed treatments plus existing DSD does not necessarily add up to the cumulative DSD for the Action Alternatives in Table 3.6-12. The cumulative DSD for the Action Alternatives takes into consideration that approximately 50% of the historic skid trails in the units with existing DSD conditions will be reused, minimizing the amount of new soil disturbance created during yarding operations. Alternative 1

Alternative 1 would not add to cumulative soil effects unless fires outside of the normal range of variability occur. Currently there are 93 acres of soils detrimentally disturbed in treatment units. There would be no additional detrimental soil effects since ground disturbing treatments such as commercial thinning would not occur. Noxious weed populations would persist except where currently authorized treatments reduce them (primarily along open system roads).

Table 3.6- 10: Alternative 2 - Proposed Treatment Units Detrimental Soil Disturbance Calculations

Unit	Treatment	Fuels RX	Acres	Existing DSD (%)	Logging System Commercial Units (Acres) GB	SKYLINE	TLM	Temp Road (ft)	TLM Trail (ft)	Exc. Skid Trail (ft)	Landing (Acres)	DSD from Proposed Treatment (%)	Cum. DSD (%)	Cum. DSD (Acres)
1	Uneven Age Management	RX burn for site prep	42	5%	33					311	0.8	13%	15%	5
3	Intermediate Harvest	RX burn	20	2%	20					86	0.3	11%	12%	2.5
4	Group Selection	Burn activity fuels	10				5		824			9%	9%	0.4
5	Group Selection	RX burn	24				10		2826			12%	12%	1.2
6	Group Selection	Burn activity fuels	21			8					0.7	13%	13%	1
8	Intermediate Harvest	RX burn	38				38		2933		2.0	11%	10%	4.3
9	Intermediate Harvest	Burning of activity fuels	21	5%	21						0.5	12%	15%	3.1
10	Intermediate Harvest	Rx burn	59	2%	35						0.5	11%	12%	4.4
12	Uneven Age Management	Broadcast burn after harvest	199	5%	166						1.8	11%	14%	22.5
13	Non-Commercial Thin	RX burn	57									0%	0%	0
14	Non-Commercial Thin	RX burn	88									0%	0%	0
15	Intermediate Harvest	No burning	3				3		953			13%	13%	0.4
16	N1/2 -Group Selection & S1/2- Intermediate-Harvest	Burning of activity fuels	17				16		1762			7%	7%	1.1
17	Intermediate Harvest	RX burn	21	2%	13						0.3	12%	13%	1.7
18	Intermediate Harvest	RX burn	29	5%	29						0.5	12%	14%	4.1
19	Intermediate Harvest	RX burn	14			14					0.7	9%	9%	1.3
20	Intermediate Harvest	RX burn	8	2%		8		1950				11%	12%	0.9
21	Intermediate Harvest	RX burn	12			12					0.7	10%	10%	1.2
24	Non-Commercial Thin	RX burn	35									0%	0%	0
25	Intermediate Harvest	RX burn	15		15						0.3	12%	12%	1.8
26	Intermediate Harvest	RX burn	52	5%	52						0.8	11%	14%	7.3
27	Intermediate Harvest	RX burn	26			26					1.7	11%	11%	2.7
28	Intermediate Harvest	Slash, pile, burn	50	2%	44			2184			0.5	13%	13%	5.9

Unit	Treatment	Fuels RX	Acres	Existing DSD %	Logging System Commercial Units (Acres) GB	SKYLINE	TLM	Temp Road (ft)	TLM Trail (ft)	Exc. Skid Trail (ft)	Landing (Acres)	DSD from Proposed Treatment (%)	Cum. DSD (%)	Cum. DSD (Acres)
32	Intermediate Harvest	RX burn	9	2%	9					72	0.3	13%	14%	1.3
34	Intermediate Harvest	RX burn	17		5					68	0.25	15%	15%	0.8
36	Non-Commercial Thin	RX burn	204	20%								0	15%	30.6
38	Group Selection	RX burn	34	2%	12			1446			0.3	15%	15%	2
39	Uneven Age Management	RX burn	101	5%	75						1.0	11%	14%	10.4
41	Group Selection	RX burn for site prep	24			12					0.5	8%	8%	1
42	Group Selection	RX burn	25	2%	13						0.5	14%	15%	1.9
43	Non-Commercial Thin	RX burn	32	3%								0%	3%	0.8
45	Group Selection	RX burn	86	2%	17						0.3	11%	12%	2.1
46	Intermediate Harvest	RX burn	14				14		2318			9%	9%	1.2
47	Intermediate Harvest	RX burn	5			5					0.2	8%	8%	0.4
48	Intermediate Harvest	no burning	5		5						0.3	15%	15%	0.8
49	Intermediate Harvest	Rx burn	45	5%	31						0.5	12%	14%	4.4
50	Intermediate Harvest	RX burn	47	2%	25			1597			0.8	15%	15%	3.9
51	Non-Commercial Thin	RX burn	47									0%	0%	0
52	Group Selection	RX burn	9									0%	0%	0
53	Intermediate Harvest	RX burn	249	5%	212						1.8	11%	13%	28.3
57	Group Selection	RX burn	29	2%	6						0.3	14%	15%	0.9
58	Group Selection	RX burn	4			2		227			0.1	12%	12%	0.2
59	Intermediate Harvest	RX burn	5		5						0.3	15%	15%	0.8
60	Group Selection	RX burn	21				6		1841			12%	12%	0.7
61	Intermediate Harvest	RX burn	27	5%	35						0.3	11%	13%	4.6
62	Intermediate Harvest	RX burn	30	2%	21			2226			0.5	15%	15%	3.4
64	Non-Commercial Thin	RX burn	57									0%	0%	0
65	Intermediate Harvest	RX burn	17	2%	10			812			0.1	15%	15%	1.6
Alternative 2			Sum	Max	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Max	Max	Total
			2,004	20%	909	87	92	10,442	13,457	537	17	30%	15%	172

Table 3.6- 11: Alternative 3 - Proposed Treatment Units Detrimental Soil Disturbance Calculations.

Unit	Treatment	Fuels RX	Acres	Existing DSD %	Logging System Commercial Units (Acres) GB	SKYLINE	TLM	Temp Road (ft)	TLM Trail (ft)	Exc. Skid Trail (ft)	Landing (Acres)	DSD from Proposed Treatment((%)	Cum. DSD (%)	Cum. DSD (Acres)
1	Uneven Age Management	RX burn for site prep	26	5%	26						0.8	13%	15%	4
3	Intermediate Harvest	RX burn	20	2%	20						0.3	11%	12%	2.5
6	Group Selection	Burn activity fuels	21			8					0.7	13%	13%	1
8	Non-Commercial Thin	Rx burn	38								0%	0%	0%	0
9	Intermediate Harvest	Burn activity fuels	21	5%	21						0.5	12%	15%	3.1
10	Intermediate Harvest	Rx burn	59	2%	35						0.5	11%	12%	4.4
11	Non-Commercial Thin	Rx burn	50								0%	0%	0%	0
12	Uneven Age Management	Broadcast burn after harvest	199	5%	166						1.8	11%	14%	22.5
13	Non-Commercial Thin	RX burn	57								0%	0%	0%	0
14	Non-Commercial Thin	RX burn	88								0%	0%	0%	0
15	Non-Commercial Thin	No burning	3								0%	0%	0%	0
17	Intermediate Harvest	Rx burn	21	2%	13						0.3	12%	13%	1.7
18	Intermediate Harvest	Rx burn	31	5%	29						0.5	12%	14%	4.1
19	Intermediate Harvest	RX burn	14			14					0.7	9%	9%	1.3
21	Intermediate Harvest	Rx burn	10			10					0.7	11%	11%	1.1
22	Intermediate Harvest	Rx burn	76	2%	74						1.5	12%	13%	9.6
22	Intermediate Harvest	Rx burn	8	2%								0%	2%	0.2
23	Intermediate Harvest	Rx burn	79	2%	64						1.5	12%	13%	8.5
23	Intermediate Harvest	Rx burn	11	2%							0%	0%	1%	0
24	Group Selection	Rx burn	35								0%	0%	0%	0
25	Intermediate Harvest	Rx burn	15		15						0.3	12%	12%	1.8
26	Intermediate Harvest	RX burn	52	5%	52						0.8	11%	14%	7.3
27	Intermediate Harvest	RX burn	26			26					1.7	11%	11%	2.7
36	Non-Commercial Thin	RX burn	204	20%							0%	0%	15%	30.6

Unit	Treatment	Fuels RX	Acres	Existing DSD %	Logging System Commercial Units (Acres) GB	SKYLINE	TLM	Temp Road (ft)	TLM Trail (ft)	Exc. Skid Trail (ft)	Landing (Acres)	DSD from Proposed Treatment (%)	Cum. DSD (%)	Cum. DSD (Acres)
39	Uneven Age Management	RX burn	101	2%	75						1.0	11%	12%	9.3
40	Intermediate Harvest	RX burn	7			7					0.5	11%	11%	0.8
42	Group Selection	RX burn	25	2%	13						0.5	14%	15%	1.9
43	Non-Commercial Thin	RX burn	34	3%								0%	3%	1
45	Group Selection	Rx burn	87	2%	17						0.3	11%	12%	2.1
47	Intermediate Harvest	Rx burn	5			5					0.2	8%	8%	0.4
48	Intermediate Harvest	no burning	5		5						0.3	15%	15%	0.8
49	Intermediate Harvest	Rx burn	45	5%	31						0.5	12%	14%	4.4
50	Intermediate Harvest	RX burn	21	2%	11							10%	11%	1.2
51	Non-Commercial Thin	RX burn	7								0%	0%	0%	0
52	Non-Commercial Thin	RX burn	9								0%	0%	0%	0
53	Intermediate Harvest	Rx burn	264	5%	212						1.8	11%	13%	28.3
57	Group Selection	RX burn	30	2%	6						0.3	14%	15%	0.9
59	Intermediate Harvest	Rx burn	5		5						0.3	15%	15%	0.8
61	Intermediate Harvest	RX burn	27	5%	35						0.3	11%	13%	4.6
62	Intermediate Harvest	RX burn	16	2%	16						0.5	13%	14%	2.3
64	Non-Commercial Thin	RX burn	57									0%	0%	0
66	Non-Commercial Thin to 10" DBH	no burning	27									0%	0%	0
66A	Non-Commercial Thin to 10" DBH	no burning	19									0%	0%	0
A	Non-Commercial Thin to 10" DBH	Rx burn	29									0%	0%	0
B2	Non-Commercial Thin to 10" DBH	Rx burn	124									0%	0%	0
C2	Non-Commercial Thin to 10" DBH	Rx burn	104									0%	0%	0
E2	Non-Commercial Thin to 10" DBH	Rx burn	31									0%	0%	0
Alternative 3			Sum	Max	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Max	Max	Total
			2,243	20%	941	70	0	0	0		14	15%	15%	161

Table 3.6- 12: Alternative 4 - Proposed Treatment Units Detrimental Soil Disturbance Calculations.

Unit	Treatment	Fuels RX	Acres	Existing DSD (%)	Logging System Commercial Units (Acres)			Temp Road (ft)	TLM Trail (ft)	Exc. Skid Trail (ft)	Landing (Acres)	DSD from Proposed Treatment (%)	Cum. DSD (%)	Cum. DSD (Acres)
					GB	SKYLINE	TLM							
1	Uneven Age Management	RX burn for site prep	42	5%	33					497	0.75	13%	15%	5.0
8	Non-Commercial Thin	Rx burn	38									0%	0%	0.0
9	Intermediate Harvest	Burning of activity fuels	21	5%	21						0.5	12%	15%	3.1
10	Intermediate Harvest	Rx burn	59	2%	27						0.5	12%	13%	3.5
11	Non-Commercial Thin	Rx burn	50									0%	0%	0.0
12	Uneven Age Management	Broadcast burn after harvest	199	5%	166						1.75	11%	14%	22.5
14	NCT 10"dbh and less	RX burn	88									0%	0%	0.0
15	Intermediate Harvest	no burning	3				3		360			7%	7%	0.2
16	S1/2 Intermediate Harvest	Burning of activity fuels	17		1		7		1361			6%	6%	0.5
17	Intermediate Harvest	Rx burn	21	2%	13						0.1	15%	15%	1.9
18	Intermediate Harvest	Rx burn	29	5%	29						0.5	12%	14%	4.1
19	Intermediate Harvest	RX burn	14			14					0.7	9%	9%	1.3
21	Intermediate Harvest	Rx burn	12			10					0.7	11%	11%	1.1
22	Intermediate Harvest	Rx burn	76	2%	74						1.5	12%	13%	9.6
22	Intermediate Harvest	Rx burn	16	2%								0%	1%	0.0
23	Intermediate Harvest	Rx burn	79	2%	64						1.5	12%	13%	8.5
23	Intermediate Harvest	Rx burn	3	2%								0%	2%	0.1
28	Intermediate Harvest	Slash, pile, burn	50		44			2,184			0.5	13%	13%	5.5
32	Intermediate Harvest	Rx burn	9		9					73	0.25	13%	13%	1.2
34	Intermediate Harvest	Rx burn	17		5					69	0.2	14%	14%	0.7
36	Non-Commercial Thin	RX burn	204	20%								0%	15%	30.5
39	Intermediate Harvest	RX burn	101	5%	75						1	11%	14%	10.4

Unit	Treatment	Fuels RX	Acres	Existing DSD %	Logging System Commercial Units (Acres) GB	SKYLINE	TLM	Temp Road (ft)	TLM Trail (ft)	Exc. Skid Trail (ft)	Landing (Acres)	DSD from Proposed Treatment %	Cum. DSD %	Cum. DSD Acres
40	Intermediate Harvest	RX burn	7			7					0.5	11%	11%	0.8
43	NCT, 10"dbh and less	RX burn	34	3%								0%	2%	0.0
48	Intermediate Harvest	no burning	5		5						0.25	15%	15%	0.8
49	Intermediate Harvest	Rx burn	46	5%	31						0.5	12%	14%	4.4
50	Intermediate Harvest	RX burn	41	2%	25						0.75	13%	14%	3.5
53	Intermediate Harvest	Rx burn	254	5%	212						1.75	11%	13%	28.3
59	Intermediate Harvest	Rx burn	5		5						0.25	15%	15%	0.8
61	Intermediate Harvest	RX burn	27	5%	35						0.25	11%	13%	4.6
62	Intermediate Harvest	RX burn	25	2%	21			1,000			0.5	12%	13%	2.8
64	Non-Commercial Thin	RX burn	57									0%	0%	0.0
66	Non-Commercial Thin	no burning	27									0%	0%	0.0
70	NCT conifers > 12 in. DBH; girdle conifers >12 in DBH	pile and burn; no broadcast type burning	8									0%	0%	0.0
73	Remove all conifers on edge of clone. Within clone follow prescription for Unit 75	Rx burn	16	2%	5							10%	11%	0.6
74	Remove all conifers on edge of clone. Within clone follow prescription for Unit 75	Rx burn when soils moist; drag out slash	6	2%	6							10%	11%	0.7
75	Non-Commercial Thin + Commercial Thin (see silv prescription)	Rx burn when soils moist; drag out slash	13		3							10%	10%	0.6
A	Slash > 7 inches DBH		25		hand							0%	0%	0.0
B2	Slash > 7 inches DBH		124		hand							0%	0%	0.0
C2	Slash > 7 inches DBH		104		hand							0%	0%	0.0
Alternative 4			Sum	Max	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Max	Max	Total
			1,971	20%	909	31	10	3,184	1721	639	12	15%	15%	155

Unit = Proposed treatment unit (activity areas).

Treatment – Proposed thinning treatment. Full description of silvicultural treatments is available in Silviculture section.

Fuels RX – Fuels treatment for unit following thinning treatment. Complete descriptions of fuels prescriptions are in the Fuels section.

Acres – Total unit acres analyzed for thinning and fuel reduction treatments.

Existing DSD% - Currently DSD (Detrimental Soil Disturbance) amount in the unit based on R1 soil monitoring protocol.

Logging System Commercial Units – Acres of proposed thinning by yarding type: Ground-based, Skyline, and Track-line Machine (TLM).

Temporary Roads Feet – Proposed temporary road construction displayed in feet for routes not located on historic prism. Amount of DSD calculated based on 12-foot road base.

TLM Skid Trails Feet – Proposed TLM skid trails displayed in feet. These are trails used in TLM operations as the platform which the track-line machine sits on and decks logs. A skidder is used to drags the logs to the road system on the constructed trails. DSD calculations are based on a 12-foot wide trail base. The Como FEIS assumes the entire length of these trails will require construction. TLM trails are analyzed the same as Temporary Roads for detrimental disturbances to soils and require the same obliteration and rehabilitation following harvest activities.

Exc. Skid Trails Feet – Proposed skid trails that require excavation similar to temporary road construction. These trails will only be used to skid logs and will not be used to haul logs on log trucks. DSD calculations are based on a 12-foot wide trail base. These trails are analyzed the same as Temporary Roads for detrimental disturbances to soils.

Landing Acres – Acres of landings required for treatment of individual units.

DSD from Proposed Treatments – Potential amount of DSD caused from commercial thinning and the construction of temporary roads, TLM trails, and excavated skid trails in units. DSD estimated at 10% for Ground-based (GB) yarding (skidding) and 4% for Skyline and TLM Units.

Cumulative DSD – Cumulative DSD following all treatments. It is estimated that ground-based yarding in units with detrimentally disturbed historic skid trails will reuse approximately 50% of the historic skid trails to minimize new detrimental soil disturbance. The cumulative DSD shown in this column does not include improvements to soil productivity from rehabilitation treatments such as recontouring and revegetation activities on temporary roads, track-line machine trails, and excavated skid trails.

Alternative 2

Alternative 2 will produce additional soil disturbance that overlaps in time and space with the existing soil conditions. Fire potential, illegal OHV use, and the continuation of active grazing allotments appear to be the most likely on-going and reasonably foreseeable actions that would cumulatively affect soil resources.

Approximately 122 acres are at risk of increased soil disturbance (Table 3.6- 9) from proposed commercial thinning treatments, increasing cumulative detrimentally disturbed soils to 182 acres within treatment units across the project area. Alternative 2 has the highest amount of cumulative DSD when compared with Alternatives 3 and 4 due to the increased level of temporary road, track-line machine trail, and excavated skid trail.

Alternative 3

Alternative 3 will also produce additional soil disturbance that will overlap in time and space with the existing soil conditions. Fire potential, illegal OHV use, and the continuation of active grazing allotments would be the most likely on-going and reasonably foreseeable actions that would cumulatively affect soil resources.

Approximately 111 acres are at risk of increased soil disturbance (Table 3.6- 9) from proposed commercial thinning treatments, increasing cumulative detrimentally disturbed soils to 161 acres within treatment units across the project area. No temporary road, track-line machine trail, or excavated skid trail construction is proposed for Alternative 3, which greatly reduces the cumulative DSD for each unit.

Alternative 4

Similar to Alternatives 2 and 3, Alternative 4 will produce additional soil disturbance that overlaps in time and space with the existing soil conditions. Fire potential, illegal OHV use, and the continuation of active grazing allotments appear to be the most likely on-going and reasonably foreseeable actions that would cumulatively affect soil resources.

Approximately 106 acres are at risk of increased soil disturbance (Table 3.6- 9), increasing cumulative detrimentally disturbed soils to 155 acres within treatment units across the project area.

Cumulative DSD Effects and Long-Term Soil Productivity

Coarse textured soils on the Bitterroot NF have displayed considerable resiliency to intensive past disturbances from logging, terracing, and road construction. Several studies of the effects of harvest and mechanical site preparation on soil properties and productivity have been undertaken on the Bitterroot NF. The results of these studies indicate that long-term soil productivity is not negatively affected, and in some cases is improved, as measured by ponderosa pine growth (Cerise et al. 2013, Zlatnik et al. 1999).

An excerpt from Cerise et al. 2013 states:

> "Standard and terracing site preparation techniques on the BNF (Bitterroot NF) did not express detrimental impacts on timber productivity after 45 years on sites in our study area. Our results show that bulk density among the harvested and terraced plots was not different from unharvested stands illustrating that these soil types have recovered to pre-disturbance levels. Changes in soil bulk density also did not appear to have had a significant impact on ponderosa pine seedling establishment

and growth. Soil disturbance on both mechanically prepared treatments was still detectable but appeared to be recovering from the previous disturbances. However, there was reduced understory vegetation cover, species diversity, and reduced forest floor biomass and OM (organic matter) content on the mechanically treated locations."

This study focused on terraced plantations and non-terraced plantations that were dozer scalped for planting following clear cutting from 1965 to 1972. The terracing and dozer scalping of these units displaced and compacted extensive portions of the units. Topsoil and organic horizons were displaced and mixed at depth in most cases, leaving bare mineral, biologically inert sub-soils exposed in most areas. These harvest units visually resembled heavily disturbed mine sites. Using current soil monitoring protocol these terraced and dozer scalped units probably ranged from 50% to nearly 100% detrimentally disturbed following the site preparation (Figure 3.6- 1).

***Figure 3.6- 1*: View of Terraced Plantation folLowing Clear cutting and Construction of Terrace benches. Extensive soil displacement and compaction resulted from this method of site preparation. Recent research indicates that soil productivity has recovered from the past disturbances (Cerise et al. 2013).**

The practices of terracing and dozer scalping were completed following clear cutting to improve the establishment and survival rates of plantings. The extensive soil disturbance was effective at reducing competition from other vegetation which was one of the greatest limiting factors to survival of planted trees (particularly ponderosa pine). Current

harvest and silvicultural practices are designed with soil conservation as a critical component and do not result in soil disturbance shown in Figure 3.6-1. Current harvest technology and practices typically stay well within R1 SQS, often less than 10% DSD even for summer ground-based yarding. Harvest design features involving seeding and slashing of disturbed skid trails greatly reduces soil disturbance in the short term and speeds recovery of the disturbed sites.

The research conducted by Cerise et al. (2013) indicates that the heavily disturbed terrace and dozer scalped sites have reduced understory vegetative cover, vegetative diversity, forest floor biomass, and organic matter content. As previously mentioned, today's harvest practices are designed to protect and conserve soil. Large-scale displacement and mixing of organic matter and topsoil are not acceptable practices. Harvest design features that facilitate soil recovery limit negative effects on understory vegetative cover and diversity, forest floor biomass, and soil organic matter so that recovery to pre-disturbance conditions is achieved in the long-term.

Alternatives 2, 3, and 4 have commercial thinning units that exceed R1 SQS (see Table 3.6-10, Table 3.6- 11 and Table 3.6- 12). The soil disturbance from yarding and the construction of temporary roads, track-line machine trails, and excavated skid trails is considered detrimental but effects are short-term and not expected to persist. As indicated by Cerise et al. (2013), even the most extreme cases of detrimental soil conditions that have often been considered as irreversible effects are capable of recovery in the long-term. Soil monitoring of commercial thin units, 3 to 5 years after harvest activities and rehabilitation of features such as temporary roads typically shows that DSD is reduced by more than half of the DSD present immediately after harvest over this time period (2005-2012 Forest Plan Monitoring). Figure 3.6- 2 provides a view of a recently commercially thinned unit using summer ground-based yarding.

In the current era of resource management and harvesting practices, additional emphasis is given to the season of harvest, ensuring that equipment operations are limited to designated areas, and that post-harvest activity does not reduce site and soil productivity. Conservation of soil organic matter and coarse woody material are considered in every project. Skid trails used in current harvest operations are rehabilitated with waterbars, slash placement, seeding with a native seed mixture, and fertilizing with an organic, slow release fertilizer to speed natural recovery and keep nutrients and soil on site.

3.6.6 Regulatory Framework and Consistency

3.6.6.1 Region 1 Soil Quality Guidelines and Region 1 Supplement 2500-99-1 (R1 SQS)

The R1 SQS 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. R1 SQS state that activities within harvest areas should be designed to detrimentally disturb less than 15 percent of the activity area.

All Action Alternatives have commercial thinning units that exceed the R1 SQS.

Figure 3.6- 2: View of a Recently Harvested Stand on the Bitterroot NF Immediately Following Log Yarding. This unit was commercially thinned in 2013. Summer ground-based yarding using a skidder moved the logs to the landings. Skid trails can be seen in the photo. Slash and duff material were placed on these trails following yarding to speed recovery. All the skid trails with exposed mineral soil were seeded with a native seed mixture. The proposed yarding practices in the Como Forest Health project would be similar and have similar results as those shown here.

3.6.6.2 Forest Plan Standards

Forest wide standards for soil resources in the Forest Plan are found in Chapter II, pages 17-33, and Chapter III under the individual management areas, page II-46. The Forest Plan does not have numeric soil quality standards; however, the plan addresses soils in the following standards and guidelines.

- Page III-6(3) Provide soils technical support for management activities on sensitive soils.

  How addressed: The Forest Soil Scientist participated on the ID Team and will participate in the implementation as needed.

- Page II-25(7) Plan and conduct land management activities so that reductions of soil productivity potentially caused by detrimental compaction, displacement, puddling, and severe burning are minimized.

  How addressed: The Forest Soil Scientist field reviewed all of the proposed units in all action alternatives for existing site conditions. Utilizing this data, the Forest Soil Scientist was able to plan, design, and prepare implementation design criteria and rehabilitation treatments to protect soil productivity. The

design criteria are found in the soils section Design Features and Mitigation Measures Common to All Action Alternatives and Chapter 2 of the document. The ID Team reviewed the design features in Chapter 2 so they are integrated between resource areas.

- Page II-25(8) Plan and conduct land management activities so that soil loss, accelerated surface erosion, and mass wasting caused by these activities will not cause an unacceptable reduction in soil productivity and water quality.

  How addressed: See above discussion under Page II-25(7).

- Page II-25(9) Design or modify all management practices as necessary to protect land productivity and maintain land stability.

  How addressed: All Action Alternatives propose commercial thinning units that will exceed R1 SQS. Modifications to the selected alternative will be required to meet R1 SQS. See Table 13.

- Page II-25(6) Soil and Water Conservation Practices (SWCPs) will be a part of project design and implementation to ensure soil and water resource protection (FSH 2509.22).

  How addressed: SWCPs (FSH 2509.22) are linked to the timber sale contract provisions to insure implementation. Timber Sale Administrators monitor the implementation of BMPs and SWCPs during sale contract period and consult with the soil scientist to address issues concerning soil disturbance.

- Page III-6(4) identifies the level of organic matter and coarse woody material following harvest.

  How addressed: Target levels for coarse woody material are found in Table 3.6- 3. The levels of coarse woody material have been modified for the action alternatives based on site-specific information (Proposed Forest Plan Amendment and the purpose and need of the project, Chapter 1). The amendment allows a quantitative measurement of the amount of coarse woody material to be left by fire group. This Forest Plan Amendment is needed because more recent research has been published since the Forest Plan was approved in 1987. Graham et al. (1994) and Brown et al. (2001) suggest a range of CWD depending on habitat type. The suggested range provides adequate CWD for soil productivity and other resource benefits without creating conditions that would lead to unacceptable fire intensity. The amended CWD requirements for this project will encompass less than 0.1 percent of the Bitterroot NF (based on maximum treatment area of 2,243 acres in Alternative 3). This amendment in combination with this project cumulatively amount to approximately 1.5 percent of the forest. The modifications of the CWD requirements for this project will not have appreciable cumulative effects at the site or forest scale.

3.6.6.3 National Forest Management Act

The National Forest Management Act requires the Forest Service to insure that timber will be harvested only where soil will not be irreversibly damaged (16 USC Section 1604 (g)(3)(E)(i)) and even-aged regeneration harvest be carried out in a manner consistent

with the protection of soil (16 USC Section 1604 (g)(3)(F)(v)). The intent is that by maintaining productivity of the parts (i.e. the treatment units), the productivity of the land in the larger picture will thereby be maintained.

Construction of specified road is an irreversible commitment of soil productivity while the road is part of the transportation system. Decommissioning specified road and rehabilitation will restore soil and site productivity. Loss of soil productivity during construction of system road is necessary in suitable locations to provide access for forest management. Proposed activities involving construction of temporary roads, track-line machine trails, and excavated skid trails in the Action Alternatives will not result in irreversible damage to the soil resource due to rehabilitation treatments and subsequent soil recovery. Ground-based yarding can also lead to increased DSD but design features such as designating skid trails and reusing historic skid trails will limit new disturbances.

Limited data has been released from the Long-term Site Productivity Project (LTSP) (Powers et al. 2005; Powers et al. 2004). Data released from the first 10 years (Sierra Nevada and Southern Coastal Plain sites) suggests that site productivity has not been impaired despite substantial soil compaction and a massive removal of surface organic matter on the test plots (Powers et al 2004). The authors also suggest that there is no evidence that the 10 year productivity was universally impacted by soil compaction. Possible reasons for this result include that the increase in bulk density was not severe enough, bulk density changes are strongly tied to initial soil bulk density, or that increased bulk density in coarse soil increases the water holding capacity on droughty soils. The authors caution against using this information for other sites and climates and suggest that conclusions (based on 10 years of study) may change as more data is collected.

Powers (1990) defines the processes that lead to declines in soil productivity. He concludes that if the loss of biomass, organic matter, soil porosity, and topsoil is limited; soil productivity should be preserved. The Como Forest Health project protects organic matter, soil porosity, and topsoil by applying Montana BMPs, SWCPs, and design features. Localized and limited losses of soil productivity will occur on landings, skid trails, temporary roads, track-line machine trails, and excavated skid trails. However, over most of a unit and the landscape, the processes that lead to soil productivity will be preserved and rehabilitation treatments will speed recovery of disturbed sites.