Flat Vegetation Management Project

Environmental Assessment

SOIL RESOURCE SPECIALIST REPORT

Bend-Fort Rock Ranger District
Deschutes National Forest

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Project Location and Description

The Flat Vegetative Management Project is located approximately 25 miles southeast of Bend on the Bend/Fort Rock District of the Deschutes National Forest. The project area contains approximately 20,224 acres of National Forest System land along the lower southwestern flank of the Newberry Mountain complex and lies within the Long Prairie subwatershed (T.23S., R.11E., Willamette Meridian). The project area lies within the boundaries covered by the Eastside Screens.

Proposed Actions affecting the Soils Resource

Proposed actions include vegetation management activities intended to improve vegetative resiliency to large-scale disturbance events such as insect, disease and wildfire. Overstory and understory treatments would be implemented to reduce forest vegetation density and address tree species composition in stands proposed for management under this project. Fuels treatments would be implemented to reduce fuels already on site or generated by the overstory and/or understory treatments. The proposed action includes approximately 7,319 acres of overstory harvest treatments; approximately 6,181 acres of understory treatments; and approximately 6,140 acres of fuels treatments. Alternative 3 includes 6,487 acres of overstory treatments and 6,146 acres of understory treatments, as well as 63 acres of fuels only treatments.

Overstory treatments include commercial thinning, uneven-aged management, final removal, overstory removal with salvage, clearcut with seed trees with salvage, girdle overstory, and shelterwood harvest. Understory treatments include pre-commercial thinning, ladder fuels reduction, whip felling, and skid and decking of biomass material in plantations. Fuels treatments include the hand and machine piling, lop and scatter, mastication, mowing and/or underburning of excess live and dead biomass already on site or generated by overstory and understory treatments.

Proposed activities that would affect the soil resource include the mechanized harvest and yarding of trees, pre-commercial hand or mechanical thinning, machine and/or hand piling of slash materials, mowing or mastication of brush and understory trees, burning of slash piles and prescribed fire to reduce hazardous fuel accumulations. The proposed action would also create approximately 15.9 miles of temporary road, primarily on previously disturbed ground or on ground disturbed during the creation of skid trails under this project. Road maintenance or reconstruction of haul routes would also occur.

Specific actions with potential effects to the soil resource include:

1) Mechanized cutting and yarding of commercial material on approximately 7,138 acres using a feller buncher/grapple skidder or a cut to length harvester/forwarder system. This includes 4,680 acres of commercial thinning and approximately 2,459 acres of other silvicultural prescriptions, including selection cuts, overstory removal and shelterwoods.

Cutting machinery would be limited to designated trails or limited single out and back passes off of trails. Skidding operations would be restricted to existing or designated logging facilities (i.e., skid trails, landings) and roads.
2) Small tree treatments on approximately 12,885 acres, approximately 6,584 of which overlap with overstory treatment acres. These treatments include hand or mechanical thinning of pre-commercial material with possible mechanical removal.

3) Machine piling of non-commercial material on approximately 3,492 unit acres under limited machine travel off of developed skid trails or landing areas.

4) Road Maintenance or reconstruction on approximately 8.6 miles of arterial and collector roads.

5) The creation of approximately 15.9 miles of temporary road to provide access for hauling commercial material from proposed unit areas. Most of these miles would occur on skid trails created during the harvesting activities or on ground previously disturbed by railroad era logging or ground-based harvest activities in the past 30 years. All temporary roads would be closed and/or obliterated upon completion of harvest activities; No newly constructed system roads would occur.

6) Mowing or mastication of shrubs and small trees on approximately 5,913 and 5,776 acres, respectively using a small ASV or tractor mower;

7) Soil restoration treatments (subsoiling) may be implemented on temporary roads where conditions are determined to be appropriate for this operation. Subsoiling of skid trails and landings may occur within units determined to have detrimental soil disturbance on greater than 20% of unit acreage following harvest and fuels treatments.

8) Underburning of approximately 3,332 unit acres to reduce the continuity and height of fuel loads across the landscape.

**Management Direction**

The Deschutes Land and Resource Management Plan (LRMP) includes Forest-wide standards and guidelines that direct land management activities to promote the maintenance or enhancement of soil productivity. Forest Standards and Guidelines applicable to this project include:

1) leaving a minimum of 80 percent of an activity area in a condition of acceptable productivity potential following the implementation of proposed activities (Forest Plan Standard and Guidelines SL-1 and SL-3; p. 4-70);

2) the use of rehabilitation measures when the cumulative impacts of management activities are expected to cause damage exceeding soil quality standards and guidelines on more than 20 percent of an activity area (SL-4); and

3) limiting the use of mechanical equipment in sensitive soil areas (SL-5).

The Pacific Northwest Region developed soil quality standards and guidelines to limit detrimental soil disturbances associated with management activities (FSM 2520, R-6 Supplement No. 2500-98-1). Region 6 guidance supplements the Forest LRMP standards and guidelines designed to protect or
maintain soil productivity and describes detrimental soil impacts as those that meet the criteria described below:

**Detrimental Compaction**: for volcanic ash/pumice soils - an increase in soil bulk density of 20 percent, or more, over the undisturbed level.

**Detrimental Puddling**: loss of soil structure when the depth of ruts or imprints exceeds six inches.

**Detrimental Displacement**: the removal of more than 50 percent of the A horizon from an area greater than 100 square feet, which is at least 5 feet in width.

**Severe Burned Damage**: soils are considered to be detrimentally disturbed when the mineral soil surface has been significantly changed in color, oxidized to a reddish color, and the next one-half inch blackened from organic matter charring by heat conducted through the top layer.

The Regional supplement to the Forest Service Manual (FSM 2520, R-6 Supplement No. 2500-98-1) provides policy for planning and implementing management practices which maintain or improve soil quality. This Regional guidance is consistent with Deschutes LRMP interpretations for standards and guidelines SL-3 and SL-4 that limit the extent of detrimental soil conditions within activity areas.

When initiating new activities:

1. Design new activities that do not exceed detrimental soil conditions on more than 20 percent of an activity area. (This includes the permanent transportation system).

2. In activity areas where less than 20 percent detrimental soil impacts exist from prior activities, the cumulative amount of detrimentally disturbed soil must not exceed the 20 percent limit following project implementation and restoration.

3. In activity areas where more than 20 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and restoration must, at a minimum, not exceed the conditions prior to the planned activity and should move conditions toward a net improvement in soil quality.

**Desired Landscape Condition**

The primary management goal for the soil resource is to maintain or enhance soil conditions at acceptable levels without impairment of the productivity of the land. A desirable landscape includes a soil resource that effectively absorbs and distributes water, and is capable of supporting vegetation to a degree that erosion rates occur within natural ranges of variability. The extent of detrimental soil disturbances should be within acceptable limits as defined by the Forest Plan and any further detrimental disturbance should be minimized through the application of Forest Plan management requirements, Best Management Practices (BMPs) and mitigation measures designed to minimize, avoid or eliminate potentially significant impacts. The biological productivity of the soil resource is ensured by management prescriptions that retain adequate supplies of surface organic matter and coarse woody debris without compromising fuel management objectives or the risk of soil damage.
from surface wildfire. Proposed activities would be implemented using specific design criteria and BMPs in order to reduce the need to restore and rectify impacts in site-specific areas.

**Issues regarding the Proposed Actions**

Key issues regarding the Flat Vegetation Management Project were originally identified by the Interdisciplinary Team (IDT) and emphasized by the public during scoping. Key issues are used to formulate alternatives, prescribe mitigation measures, and analyze the environmental effects of management activities. The maintenance of soil productivity was identified internally as an element of the soil resource that could be affected by the proposed activities. Although the issue of soil productivity was not used to formulate alternatives, project planning must include provisions for mitigation of ground disturbances where activities are expected to cause resource impacts that may exceed Regional and LRMP standards and guidelines. A summary of the soil productivity issue, including background information and measures used for tracking this issue, is provided below.

**Issue Statement:** Ground-based equipment can affect soil productivity by increasing the amount and distribution of detrimental soil conditions within individual activity areas proposed for mechanical treatments.

**Background:** The long term sustainability of forest ecosystems depends on the productivity and hydrologic function of soils. Ground disturbing management activities can directly affect these soil processes by compacting and displacing soil to a degree that may adversely affect the natural capability of soils to support vegetation and hold plant available water in the profile. The reduction of soil porosity as a result of compaction, and/or the displacement of organic or mineral surface layers, can reduce the soils ability to supply nutrients, water, and air necessary to support soil microorganisms and the growth of vegetation. The biological productivity of the soil resource can also be affected by the amount of surface organic matter and coarse woody debris retained or removed from a site. These changes may also affect the resiliency of the soil to future use and management.

**Soil Productivity Issue Measures:**

- Changes to the extent of detrimental soil conditions following proposed mechanical harvest and mitigation treatments within individual activity areas.

- Amount of coarse woody debris (CWD) and surface organic matter that would likely be retained to protect mineral soil from erosion and provide both short and long-term nutrient supplies for maintaining soil productivity on treated sites.

- The probable success of the design and implementation of management requirements, BMPs and mitigation measures to minimize adverse impacts to soil productivity.
AFFECTED ENVIRONMENT

Landscape and Soil Characteristics

The Flat project area is located on the southwestern flanks of the Newberry Mountain complex just east of the LaPine basin. The landforms and rocks are primarily products of volcanism from the Newberry complex, including a number of basaltic andesite flows sourced from local cinder cones associated with faults in the area. These landforms have been slightly dissected by water flow during a previously wetter environment. An older shield complex forms Green Butte in the southeastern portion of the project area that correlates to basaltic andesites sourced from mafic vents associated with the Cascade Range. A large southeast to northwest trending fault comprises the southeastern margin of this complex. The majority of the planning area has gentle slopes ranging from 2 to 10 percent, with steeper slopes exceeding 30% found on cinder cones, fault margins and the higher slopes of the Green Butte shield complex. Elevation ranges from about 5,785 feet on top of Green Butte to 4,260 feet at the west end near the town of Lapine. Mean annual precipitation ranges between 15 and 25 inches.

Dominant surface soils have developed from a thick layer of volcanic pumiceous ash ejected from Mt. Mazama 7,600 years ago that ranges in depths up to 40 inches. Surface and subsurface textures are primarily sandy loams and loamy sands. Mineral soil consists mainly of sand-sized soil particles with little or no structural development due to the relatively young geologic age of the volcanic ash tephra. Soils are non-cohesive (loose) and have naturally low bulk densities with a relatively low to moderate susceptibility to compaction. Soils within the project area have high infiltration and percolation rates that readily drain excess moisture from storm events or snowmelt. Subsurface bedrock materials and underlying residual soils comprised of older ash have a moderate capacity to store water but are not likely to be impermeable at depth. Lands within the project area yield no surface water.

Landtype Interpretations

The Soil Resource Inventory (SRI) of the Deschutes National Forest describes landtype units that were mapped across the entire forest (Larsen, 1976). The landtypes described in the SRI are based on similarities in soil, landforms, geology, and climatic conditions that influence defined patterns of soil and vegetation. Landtypes mapped in the Flat project area include SRI units 7, 8, 15, 41, 45, 66, 68, 70, 76, 81, 97, 6B and complexes LK (64, 68), LP (70, 6B), XM (70, 15), and XP (81, 82, 9). These landtypes generally describe a thick layer of pumiceous ash over a variety of lava plains, outwash plains, cinder cones or lava domes. The majority of these landtypes have relatively gentle slopes, except for the steeper sideslopes of cinder cones and scarps. Landtypes 7 (barren flats), 15 (lodgepole basins) and 81 (steep cinder slopes) have soils sensitive to management that include limitations to regeneration (Landtypes 7 and 15) and ground based mechanical harvest (Landtype 81).

The biophysical characteristics of SRI landtype units can be interpreted during planning to identify the productivity potentials and management suitability of the soil resource along with the potential hazards related to implementing proposed management activities. Soils within the project area generally have a moderate to high inherent productivity, with 7,519 acres of High, 11,183 acres of Moderate and 1,516 acres of Very Low productivity. Landtype 7 does not support a commercial forest, while landtypes 15 and 18 have regeneration issues that may preclude aggressive vegetative management prescriptions.
Potential hazards associated with implementing management activities include the susceptibility of the soil resource to compaction, displacement, and erosion as a result of mechanical disturbances. The project area is generally covered by a thick layer of loose, non-cohesive pumiceous ash deposits from Mt. Mazama that are moderately susceptible to compaction from mechanical disturbances. The bulk density or strength of the mineral soil is typically affected by mechanical forces that change the soil porosity within the profile. Surface soils in the project area have sandy loam textures with little or no structural development within the principal rooting zone (4 to 12 inches in depth) where changes in soil compaction (bulk density) are assessed according to Regional direction (FSM 2521.03). Multiple passes of harvest, yarding and piling machinery can reduce soil porosity and increase the soil strength of sandy loam soils to levels that affect vegetative growth.

Compacted conditions can be mitigated by physical tillage with a winged subsoiler when soil profiles have moderate to low rock content (Powers, 1999). Landtypes with a thick layer of pumiceous ash in the project area are highly suited for tillage treatments (subsoiling) to restore the strength and infiltration capabilities of the soil profile in areas of multiple machine passes such as skid trails and landings. Subsoiling, where appropriate, loosens compacted soil layers and improves the soils ability to supply nutrients, moisture, and air that support vegetative growth and biotic habitat for soil organisms. Subsoiling may not be available as a mitigation restoration measure in some areas due to steep slopes, rock content or shallower surface depths. The predominantly sandy-loam textured soils within the project area are not susceptible to soil puddling damage due to their lack of plasticity and cohesion.

Soils in the project area are moderately to highly susceptible to displacement due to the presence of coarse textured surface layers that are loose and non-cohesive. Surface organics and A horizon mineral soil can be easily displaced by equipment operations, especially when machinery maneuvers on slopes during dry moisture conditions. Landtypes 81 and 82 are most at risk of displacement due to their steeper slopes, however, the extent of displacement is generally localized on slopes less than 30% and observed to be rarely in excess of acceptable LRMP and R6 standards for these soils.

Surface erosion by water is of low to moderate concern within the project area. Surface erosion occurs at very low rates within the project area because of high infiltration rates, moderate slopes and sufficient vegetative cover and organic litter layer accumulation on the surface. However, soils derived from volcanic ash are easily eroded by raindrop impacts and overland flows when bare mineral soil is exposed by machine disturbances. As a result, landtypes on steeper slopes have moderate erosion hazard ratings that reflect potential erosion rates during thunderstorms following disturbances that reduce vegetative cover, displace organic surface layers, or reduce soil porosity through compaction.

Land Suitability and Inherent Soil Productivity

The suitable lands database for the Deschutes National Forest LRMP identifies areas of land which are considered to be suitable for timber production using criteria affecting reforestation potential (FSH 2409.13). This data was developed to designate a broad-scale timber base area for forest-wide planning purposes. Lands that do not meet these criteria are considered unsuitable or partially suitable for timber harvest due to regeneration difficulties or the potential for irreversible damage to resource values from management activities. All activity areas proposed for commercial and/or non-commercial thinning treatments in the Flat planning area meet the criteria for land suitability that would allow them to be regenerated or resist irreversible resource damage. None of the proposed activity areas have landtypes with site conditions and soil properties considered to be unsuitable for
timber production. Dominant landtypes within the Flat planning area generally have moderately deep to deep, ash-influenced soils with moderate or high productivity ratings.

**Sensitive Soil Types**

Criteria for identifying sensitive soils are included in the Deschutes Forest Plan (Deschutes LRMP (Appendix 14, Objective 5). Sensitive soils within the Flat project area are listed in **Table 1** and include:

1) Soils on slopes greater than 30% [SRI landtypes 18, 81 and complex XP (81, 82 and 9)]

   Landtypes 18, 81 and 82 are confined to cinder cones within the project area.

2) Soils with frost pockets (SRI landtypes 7 & 15). Areas defined by landtype 7 include barren pumice flats in the central portion of the project area that do not support commercial forest. Landtype 15 defines the lodgepole community type surrounding the barren flats with a high susceptibility to frost that is likely to affect regeneration activities.

It is emphasized that only portions of the acres listed in Table 1 for landtype 18 contains sensitive soils. Other landtypes in the project area have localized areas of slopes exceeding 30% within the SRI map unit that can be queried out from the Digital Elevation Model (DEM) in GIS. Areas of slope exceeding 30% have high ratings for surface erosion when surface mineral soil is disturbed or vegetative and litter cover is lost. Sensitive soil areas that occur within proposed activity areas are discussed under the direct and indirect effects of implementing the management activities proposed under Alternative 2.

**Table 1: Landtype Acres that contain localized areas of Sensitive Soils within the Flat project area (Soil Resource Inventory, Deschutes National Forest, 1976)**

<table>
<thead>
<tr>
<th>SRI Map Unit Symbol</th>
<th>Geomorphology (Representative landforms)</th>
<th>Type of Concern**</th>
<th>Landtype Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>81, 82</td>
<td>Steep slopes on cinder cones</td>
<td>1</td>
<td>598</td>
</tr>
<tr>
<td>7, 15</td>
<td>Concave micro basins</td>
<td>2</td>
<td>1,402</td>
</tr>
</tbody>
</table>

**Management Concerns**

1) On slopes greater than 30 percent, loose sandy soils are susceptible to soil displacement.

2) Frost pocket potential

**EXISTING CONDITION OF THE SOIL RESOURCE**

The existing condition of the soil resource reflects the extent of detrimental conditions incurred by natural and managed disturbances within the area. Natural disturbances such as wildfire and wind events have not been observed to directly incur extensive impacts to the soils on the Deschutes National Forest but are often followed by mechanical harvest activities capable of incurring detrimental impacts. Timber harvest and road building activities, and recreation are management disturbances that can alter soil porosity and the quantity and quality of organic matter on the soil surface. These activities can change soil quality by displacing organic surface layers, incurring soil compaction or removing vegetative cover.
**Natural Disturbances**: There is currently no evidence of detrimental soil conditions from natural disturbance events within the Flat project area. No major windthrow events have occurred within the project area and landslides are not a disturbance regime in this location. Fires within the project area include a number of events in the 1920’s and the largest one in 1977 on Green Butte. Current levels of coarse woody debris on the surface are variable, primarily dependant on forest community type and the extent of mistletoe and beetle activity within a stand. Existing vegetation and forest litter are providing adequate sources of ground cover to protect mineral soil from water and wind erosion. As a result of these conditions, natural soil disturbances were not observed to be existing sources of detrimental soil conditions within any of the activity areas proposed for this project.

**Management Disturbances**: Timber harvest is the primary management disturbance within the project area. 1943 aerial photographs show extensive dendritic and parallel networks of skid trails created by ground-based railroad logging used to harvest large-diameter ponderosa pine throughout the project area during the 1930’s and 1940’s. The vast majority of stands proposed for harvest under this project were harvested during this period. Soil probes and the productivity of existing black bark stands in these areas indicates that natural processes have gradually restored soil quality over the past 60 to 70 years. Skid trails from the railroad era that were not converted to existing system roads are not readily observable on the ground due to the presence of vegetation and forest litter. Skid trails from this era that can be located have generally returned to near-natural density levels as a result of frost heaving, wetting-drying cycles, rodent activity and root penetration throughout the deep profiles.

Many stands within the project area were re-entered during the 1970s, 80s and 90s under clear cut (HCC), commercial thinning (HTH) and overstory removal (HOR) harvest prescriptions. The extent of disturbance to the soil resource varies from these activities but detrimental soil conditions generally cover 15% of these areas. Skid trails from more recent mechanical harvest are identifiable on the ground and retain detrimentally compacted conditions.

**Existing Condition Assessments**: A combination of harvest history, site visits and field investigations of previously managed areas was used to estimate or measure existing soil conditions within the proposed Flat unit areas. Each unit was assessed for the presence, pattern and percentage of unit area previously covered by the railroad era skid trails and logging facilities using 1943 aerial photographs (Table_3.3). Railroad era harvest is evident within the majority of proposed activity units. An estimated 5% of each unit area with past railroad era logging systems was attributed with detrimental impacts as a result of observations of these areas in the field.

Proposed Flat units were additionally queried for the occurrence of more recent harvest prescriptions from the Forest Service Forest Activity database (FACTs). The majority of proposed units have past harvest prescriptions that overlap 75% or more of their acreage and exhibit detrimental soil disturbance as a result of compaction from machine harvesting and yarding operations. Five of these units were quantitatively monitored for detrimental soil disturbance levels in order to build a representative cross section of impacts from these activities within the Flat planning area. Visual assessments and shovel probes were used to record surface soil disturbance and compaction levels at 5 foot intervals along transects within these units. One unit with only records of railroad era harvest was also monitored. Results of the soil monitoring are summarized in Table_2.
Table 2 Monitoring of past Harvest Activities within the Flat planning area

<table>
<thead>
<tr>
<th>Activity Name</th>
<th>Flat Unit #</th>
<th>Year of Harvest</th>
<th>Harvest Prescription</th>
<th>Unit Acres</th>
<th>Measured Detrimental Soil Disturbance (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bark #4</td>
<td>(Flat #137)</td>
<td>1997</td>
<td>HSV - Salvage</td>
<td>51</td>
<td>18%</td>
</tr>
<tr>
<td>N.Ipsoot LP #11</td>
<td>(Flat #136)</td>
<td>1990</td>
<td>HCR -</td>
<td>52</td>
<td>20%</td>
</tr>
<tr>
<td>Finley Butte #25</td>
<td>(Flat #35)</td>
<td>1980</td>
<td>HTH - Black Bark Thinning</td>
<td>64</td>
<td>16%</td>
</tr>
<tr>
<td>Howl #17</td>
<td>(Flat #64)</td>
<td>1999</td>
<td>HTH - Black Bark Thinning</td>
<td>95</td>
<td>15%</td>
</tr>
<tr>
<td>W Sand Flat #1</td>
<td>(Flat #150)</td>
<td>1975</td>
<td>HPR – Partial removal</td>
<td>70</td>
<td>18%</td>
</tr>
<tr>
<td>Railroad Logging</td>
<td>(Flat #24)</td>
<td>1930s</td>
<td>Clear Cut</td>
<td>80</td>
<td>6%</td>
</tr>
</tbody>
</table>

Existing detrimental disturbance levels measured within units monitored with FACTS prescriptions over the last 40 years range from 15 to 20%. Past activities with HOR, HFR, HCC and HTH prescriptions were able to utilize the extensive system of railroad era skid trails and landings for their logging facilities in most of the proposed Flat units with previous entry from this era. As a result, impacts from these activities were generally localized to previously disturbed ground. Conditions within the HTH units averaged 15% and were determined to be representative of conditions in other unit areas covered by this prescription. These conditions are also representative of conditions likely to be incurred by the HTH prescriptions proposed for the Flat project in units that have not had entry since the railroad era activities. The slightly higher levels measured in the HSV and HCR units is indicative of larger volumes removed and the low levels measured in the Railroad Era logging only indicates that the soil resource has recovered substantially from detrimental disturbances incurred nearly 70 years ago.

Field monitoring of past activities in the subset of units listed in Table 2 was determined to be representative of existing conditions for other Flat units with similar harvest history. As a result, soil disturbance levels from field monitoring were used to represent existing levels of impact in the other previously entered units with similar harvest prescriptions. The Flat Units Soils Table in Appendix A summarizes the harvest history and existing detrimental soil conditions for the proposed Flat activity units.

Site Preparation and Reforestation Activities: Mechanical disturbances from site preparation and reforestation activities can also reduce site productivity through soil compaction and displacement of surface organic layers. Reforestation activities within the project area were primarily hand planting on relatively bare ground and incurred very little peripheral damage to the soil resource. It is expected that much of the original ground disturbance was likely grubbing of shrubs and bunch grasses. Planting density appears to average 12 by spacing and growth rates are likely slowing as result of competition rather than soil disturbance. Landtypes within these areas have moderate productivity ratings with site index values that range from 50 to 80 for ponderosa pine.
Roads and Rock Borrow Pits: Approximately 113 miles of existing system roads cross through the project area. This equates to approximately 205 acres currently dedicated to system roads or <1% of the 20,224 total acres within the project area. The amount of detrimentally disturbed soil committed to existing system roads is included in the estimated percentages displayed in the Flat Units Soils Table in Appendix A. Road surveys have been conducted to identify where improvements may be necessary to correct drainage problems on existing system roads that would be used as haul routes for this project. The project area contains no borrow pits within proposed activity area boundaries.

Recreation Activities: Current recreational activities in the planning area include dispersed camping and OHV riding on roads and user created trails within the project area. The extent of detrimental soil conditions associated with recreation use is minor in comparison to the transportation system and past logging disturbances.

Coarse Woody Debris (CWD) and Surface Organic Matter: Balancing fuel management objectives and adequate amounts of CWD is an important goal for maintaining long-term soil productivity. Decaying wood and organic matter on the forest floor provides biotic habitat for microorganisms and contributes to the soils ability to retain moisture and contribute to short and long-term nutrient supplies. Research studies using mycorrhizal fungi as a bio-indicator of forest soil productivity developed conservative recommendations for sufficient CWD levels following management activities (Graham et al. 1994, Brown et al. 2003). Recommendations include retaining a minimum of 5 to 10 tons per acre of coarse woody debris (greater than 3 inches in diameter) on dry, ponderosa pine sites and 10 to 15 tons of CWD per acre on mixed conifer sites to maintain soil productivity.

Conserving surface litter (i.e., organic materials such as leaves, twigs and branches less than 3 inches in diameter) is also important for maintaining soil productivity. Surface litter provides on-site moisture retention, protects mineral soil from erosion and supplies nutrients that support the growth of vegetation and native populations of soil organisms. Surface litter can also buffer the effects of soil compaction from machine traffic. Annual deposition of shrub leaves, conifer needles, and small woody forest litter have generated sufficient organic matter levels on all sites for short-term nutrient cycling and productive growth of these stands.

The effects of management activities on long-term soil productivity can also be measured by the amount of coarse woody debris (CWD) and surface organic matter retained or removed from a site. Current levels of CWD and surface litter vary between the proposed activity areas, with heaviest amounts within activity units with an HSV prescription where mortality is high as a result of beetles and mistletoe. Although CWD <10” may be removed as part of the contract in these units, there are sufficient amounts of CWD >10” that would be retained in these units to provide microsite habitat for microbial functions on site. The majority of proposed units are homogeneous black bark stands that currently have relatively low amounts of CWD on site, all of which would be retained.

Project Design and Mitigation: Cumulative levels of existing and predicted amounts of new soil disturbance need to be considered to determine whether soil quality standards will be met following project implementation. For activity areas that have already been impacted by previous management, project plans need to include options for avoiding, reducing, and mitigating adverse impacts from project activities to meet soil quality standards (see Mitigation Measures and Project Design Criteria).
ENVIRONMENTAL EFFECTS ANALYSIS

Scope of the Analysis

The soil resource may be directly, indirectly, and/or cumulatively affected by actions proposed under the alternatives of the Flat Environmental Assessment. The scope of the soil resource effects analysis is encompassed by the bounds of each activity area proposed within the project area. An activity area is defined as “the total area of ground impacted activity, and is a feasible unit for sampling and evaluating” (FSM 2520 and DLRMP, page 4-71). The activity area boundaries are considered to be the smallest identified area within which measurable potential effects of different management practices would occur. As a result, the discussion of effects to the soil resource within the context of the LRMP and Regional soil quality standards are focused on the proposed units designated for silvicultural and fuel reduction treatments. The effects discussion may expand to include the entire planning area to provide additional context when relevant to watershed concerns and the issues identified for the soil resource.

The best information about the proposed actions from the EA Alternative descriptions was used in conjunction with the location of activities to analyze the potential effects on the soil resource. Issue measures identified in the planning process were evaluated with quantitative field analyses and professional judgment to compare existing conditions to the anticipated conditions resulting from implementing the proposed actions. The potential for detrimental changes to soil physical properties was quantitatively analyzed by estimating the extent (surface area) of temporary roads, log landings, and designated skid-trail systems that would likely be used to facilitate harvesting, yarding and fuels treatment activities within each of the activity areas proposed for management.

Analysis of effects to the soil resource also considered the effectiveness and probable success of implementing management requirements, resource protection measures, and Best Management Practices (BMPs) designed to avoid, minimize or reduce potentially adverse impacts to soil productivity. Professional judgment was used to evaluate changes in the amount and composition of coarse woody debris (CWD) and surface organic matter. The temporal scope of the analysis defines short-term effects as changes to soil properties that would generally revert to pre-existing conditions within 5 years or less, and long-term effects as those that would remain identifiable for 5 years or longer.

Proposed Management activities

Management activities proposed under this project include the thinning, salvage and overstory removal of forest stands, and the treatment of understory shrub layers to reduce the potential for intense wildfires and their rates of spread. Fuel reduction treatments proposed include hand thinning trees, burning or utilization of non-timber material accumulated at the landings or piled within the units, mechanical shrub/slash treatments (mowing or mastication), and the use of prescribed fire to reduce the continuity of hazardous fuels. These proposed actions are summarized at the beginning of this report.
Analysis Methods

Soil condition assessments utilize previous monitoring reports, observations of similar types of harvest systems, research references, and field surveys to predict the potential extent of detrimental soil disturbance associated with this project proposal. Estimates also account for the cruised volume removed per acre, the type of logging equipment likely to be used, the spacing of skid trails, and the extent (surface area) of temporary roads, log landings, and designated skid-trails used to facilitate yarding activities within each of the commercial thinning activity areas.

Analysis Assumptions

**Harvest operations:** Mechanical harvest and accumulation would likely be accomplished using a ground-based machine equipped with a felling head (harvester shear). Felled trees would be accumulated along the main skid trail networks by the feller/buncher and then whole-tree yarded to landings using grapple skidders. Skidding equipment would be restricted to designated skid trails at all times while mechanical shears would traffic off of trails with out and back or loop passes. Skid trail patterns from this system are generally parallel before converging in a wheel spoke pattern near the landings. A harvester/forwarder is an optional harvest system that could be utilized in place of a shear/skidder system. This system tends to create a more symmetrical, parallel designated skid trail system with fewer passes off of these trails. Machine traffic off of designated logging facilities would be limited in extent. Project design features (PDFs) included in the document limit mechanical harvesters to two or fewer equipment passes on any site-specific area between main skid trails or away from log landings.

**Fuels Reduction Activities:** Machine piling would be focused on landing areas within mechanically harvested and yarded units following the accumulation, yarding and processing of whole trees. Machine piling of thinning accumulations may also occur within some unit areas where existing levels of down wood are high and the contractor does not engage the optional contract clause to remove it. Machine traffic for additional grapple piling within units would be limited to skid trails used for yarding or . Machine piles in these units would be located on skid trails or landing areas already detrimentally compacted or mixed by the yarding and processing operations. Additional impact from these activities would be expected to be relatively minimal in extent (< 1% of the activity area).

Direct, Indirect and Cumulative Effects

The magnitude and duration of potential effects to the physical and biological parameters of soil productivity depend on the intensity of site disturbance, the timing and location of activities, and the inherent properties of the volcanic ash-influenced soils within activity areas affected by the proposed actions. Direct effects such as soil displacement and compaction from equipment operations occur at essentially the same time and place as the actions that cause soil disturbance. Indirect effects occur sometime after or some distance away from the initial disturbance, such as increased surface erosion as a result of compaction or loss of vegetative cover. Cumulative effects include all past, present, and reasonably foreseeable actions that cause soil disturbance within the same activity areas proposed with this project. The environmental effects are presented and tracked by the issue measures used to evaluate the estimated impacts on soil productivity.
Alternative 1 – Direct and Indirect Effects

**Measure #1: Detrimental Soil Disturbance:** Under Alternative 1 (No Action), the management activities proposed in this document would not take place. No additional land would be removed from production for temporary roads or logging facilities for harvest and yarding operations. There would be no cumulative increase in detrimental soil conditions above existing levels. Although disturbed soils would continue to recover naturally from the effects of past management, the current extent of detrimental soil conditions would likely remain unchanged for the short-term.

Soil productivity would not change appreciably as a result of this alternative since no management induced detrimental soil conditions would occur. The productivity of the soil resource may decrease over time in the absence of wild or prescribed fires that provide a cyclical flush of nutrients in dry forest systems (Fire Effects Summary, 2003). Although ground fuels have been reduced in some previously managed areas, fire exclusion has resulted in undesirable vegetation conditions and excessive fuel loadings in other portions of the project area (see Fire/Fuels Section). Alternative 1 would defer fuel reduction opportunities at this time. As a result, Alternative 1 has an elevated risk of future stand-replacing wildfires capable of producing intense ground-level heating as CWD is consumed.

Wildfires under this alternative are likely to incur localized detrimental changes to soil chemical, physical, and biological properties on up to 5% of the affected landscape, an extent observed in recent fires across the Deschutes National Forest. Although the extended duration of extreme temperatures would be expected where CWD on the soil surface was consumed, the “styrofoam” characteristic of the pumiceous ash prevents deep penetration of heat induced by fire, resulting in very short-term effects to the productivity of the soil. More pronounced direct effects are the loss of protective ground cover and the possibility of localized hydrophobicity, both of which increase the risk for accelerated wind and water erosion until the return of vegetative cover during the first few growing seasons subsequent to the fire. Localized increases in surface runoff and subsequent erosion are likely to be indirect effects as a result of wildfire under this alternative.

**Measure #2: Coarse Woody Debris (CWD) and Surface Organic Matter:** In the short term, the amount of coarse woody debris and surface litter are likely to increase through natural mortality, windfall, and recruitment of fallen snags over time. Short-term nutrient sources will also increase through the accumulation of small woody material from shrub and tree branches, annual leaf and needle fall, and decomposition of grass and forb plant materials. Black bark stands currently have low levels of CWD on the ground and snags or dying trees in the stand. These areas will be much slower to accumulate CWD and will likely maintain the existing levels for an extended period of time.

In the long term, the accumulation of forest litter throughout the planning area and CWD in the overstocked lodgepole stands would increase the potential for wildland fires of higher intensity capable of consuming heavy concentrations of fuel and ground cover vegetation. High-to-extreme fire hazard and potential for excessive soil heating exists when downed woody debris exceeds 30 to 40 tons per acre (Brown et al., 2003). Intense ground-level fire can adversely affect ground cover conditions and create localized areas of severely burned soil underneath consumed CWD. There would likely be a short-term increase in the potential for accelerated wind erosion and water runoff under this alternative. The loss of organic matter would be a short term impact since the nutrient transformations as a result of recent fires have been observed to generate substantial herbaceous regrowth during the first few growing seasons (B&B, Evans West fires). Over time, burned areas not salvaged would have increased levels of CWD as fire killed trees are recruited to the forest floor.
Measure #3: Project Design and Mitigation: Under Alternative 1, there would be no cumulative increase in detrimental soil conditions from the proposed management activities. Implementation of project design criteria and mitigation measures would not be necessary.

Alternative 1 - Cumulative Effects

Measure #1: Detrimental Soil Disturbance: Under Alternative 1 (No Action), there would be no immediate short term cumulative effects on detrimental soil conditions as a result of management activities. The extent of detrimental soil disturbance from past and current management activities were previously described under the Existing Condition of the Soil Resource, and there would be no increase above existing levels under this alternative. No additional land would be removed from production or detrimentally disturbed to build temporary roads and logging facilities. The amount of detrimentally disturbed soil from past management activities and committed management facilities would remain at existing levels within the planning area. There would be no cumulative change to detrimental soil disturbance levels as a result of this alternative unless wildfire incurred detrimental burn damage as a result of excessive CWD levels on site.

Measure #2: Coarse Woody Debris (CWD) and Surface Organic Matter: Under Alternative 1, the amount of coarse woody debris and surface organic matter will increase over time from current levels at a rate dependent on mortality rates of the stands and natural wind events capable of blowing trees down. Dense lodgepole stands currently have a relatively high rate of mortality and there is a ready supply of trees capable of becoming CWD during a wind event. The accumulation of CWD and forest litter in the short term would increase the risk for longer duration heating of the surface soil during wild land fires and subsequent cumulative effects to the soil resource. The black bark stands of Ponderosa Pine currently have lower rates of mortality and fewer snags to become CWD in the short term. However, these stands are susceptible to mortality agents at current stocking levels and are likely to provide an increasing source of snags and CWD in the long term.

Measure #3: Project Design and Mitigation: Under Alternative 1, implementation of project design criteria and mitigation of project-related soil disturbances would not be necessary.

Alternative 2 (Proposed Action) – Direct and Indirect Effects

The management activities proposed under the action alternatives are identified in the Alternative Descriptions (EA, Chapter 2) and the beginning of this report. Alternative 2 is designed to reduce the potential for intense wildfires and their rates of spread by implementation of commercial and non-commercial tree thinning and a combination of various fuel reduction treatments. Proposed activities would have a variety of direct, indirect and cumulative effects on the soil resource.

Issue Measure #1: Detrimental Soil Disturbance: The use of ground-based equipment for vegetation management treatments would increase the amount and distribution of soil impacts within the activity areas proposed for harvest treatments. The development and use of temporary roads, log landings, and skid trail systems are the primary sources of new soil disturbance that could affect soil productivity. Most soil impacts would occur on and adjacent to these heavy-use areas where multiple equipment passes typically cause detrimental soil compaction. Resource protection measures, including Best Management Practices (BMPs), Project Design Criteria (PDCs), and mitigations, would be applicable to all proposed activity units to assure that LRMP standards for maintaining soil
productivity would be achieved. As a result, the proposed activities are expected to avoid or minimize the extent of soil disturbance between main skid trails and away from log landings.

**Harvest Effects:** The majority of direct impacts to the soil resource from machine harvest and skidding consist of compaction of mineral soil on heavy use areas such as temporary roads, log landings, and main skid trails. Logging infrastructure would be created or re-used within approximately 7,138 unit acres to implement commercial harvest silvicultural prescriptions under this alternative. Approximately 181 unit acres would have residual trees girdled (GFR) and would not have harvest activities occur.

Research studies and local soil monitoring show that soil compaction and soil displacement account for the majority of detrimental soil conditions resulting from ground-based logging operations (Page-Dumroese, 1993; Geist, 1989; Powers, 1999; Deschutes Soil Monitoring Reports). Detrimental compaction can occur when more than 3 to 5 equipment passes over the same piece of ground occurs (McNabb and Froehlich, 1983). The nature of the direct effects to the soil resource would be similar within all units utilizing ground-based equipment to accomplish management objectives.

The logging infrastructure necessary to accommodate the ground-based harvest, skidding and processing of commercial material would cover approximately 15% of each activity area. Skid trails would comprise approximately 11 to 13% of the unit with an average disturbed width of 12 feet and an average spacing distance of 100 feet and log landings would cover approximately 2% of the unit area at an average 100 foot by 100 foot landing for each 15 acres of harvest. Soil strength on primary skid trails, landings and temporary roads would be expected to be increased on these areas of multiple machine trips as a result of the susceptibility of the ash-influenced soils throughout the project area to compressional and vibrational forces from ground based machinery. Although compaction on skid trails is not always uniform across their entire width or length, the majority of the skid trail and landing areas would have increases in soil strength capable of affecting root growth, water infiltration, and moisture holding capacity on site. As a result, the entirety of these areas are conservatively considered to be in a detrimental condition following harvest, skidding and fuels treatment activities.

Past monitoring on the Deschutes National Forest has shown that detrimental soil conditions increase each time a stand is treated with mechanical equipment (Deschutes Soil Monitoring Reports 1996, 1997, and 1999). Even with careful planning and implementation of project activities, the extent of detrimental soil conditions can be expected to increase by 5 to 10 percent with each successive entry into a stand (Craig, 2000). Additional impacts are generally a result of re-oriented skid trail networks and off trail tracks from harvester shears. Opportunities to re-use existing skid trail networks and log landings exist in the majority of proposed units and should minimize increases in the extent of skid trails and landings. However, additional impacts are likely to be incurred off trail that would temporarily push detrimental levels to or above LRMP and R6 Standards for maintaining soil productivity following harvest and skidding activities.

Additional detrimental impacts from off-trail traffic by harvester shears are expected to be localized and minimal in extent. Although off trail traffic has been observed to incur localized additional detrimental impacts within an activity area (Lower Jack Monitoring), one or two pass trips by the harvester shears off of skid trails are expected to incur only localized detrimental soil compaction and add less than 5% of the unit area to the overall levels of detrimental soil disturbance. The maneuvering of tracked equipment on dry ash soils can displace or mix the surface soil and organic matter with subsurface horizons but this displacement is typically very localized and within the regulatory threshold definitions of detrimental disturbance. Detrimental displacement requires an area
of at least 100 ft² that is at least 5 feet in width as defined by FSM 2521.03 and the R-6 Supplement. As a result, detrimental displacement is not expected to be a measurable contributor to soil disturbance levels within proposed activity areas.

In summary, predicted detrimental conditions following mechanical harvest and skidding activities within the proposed units having previous harvest prescriptions are likely to be near or above the 20% standard due to higher levels of existing impacts units. These units may need subsoiling to restore impacts from previous activities in order to meet the LRMP standards for maintaining soil productivity. Appendix A displays the percentages of existing detrimental soil conditions and the predicted detrimental conditions following project implementation for these units. Proposed Flat units with only past railroad logging and pre-commercial thinning activities are expected to meet the 20% LRMP standard for maintaining soil productivity as a result of low existing detrimental conditions. The mechanical harvest of similar thinning levels in other black bark stands on the Forest has incurred detrimental impacts on 15 to 20% of an activity area when implemented on ground with low existing impacts. Impacts within the units planned for mechanical thinning (HTH) and the removal of dead (HSV) as part of their prescription (857 unit acres) are expected to incur only slightly higher levels of disturbance from additional off trail traffic. The predicted level of impact for all units are included in the Soils summary table in Appendix A.

**Temporary Roads:** A total of 15.9 miles of temporary road would be constructed to access and haul proposed activity units under this alternative. The majority of these would be placed on roads or skid trails from past activities that are currently detrimentally impacted. Some of these miles would be on skid trails created during these proposed activities. These roads would be subject to multiple trips by skidders and/or log trucks and incur short term direct effects in the form of compaction and displacement on approximately 29 acres of soil within the specific unit areas.

All temporary road surfaces would receive restoration treatments following their use to rehabilitate compacted and displaced conditions. Treatments would include subsoiling to de-compact subsurface and surface layers, or the use of the bucket rake of an excavator to de-compact the surface horizon, replace woody material to provide cover, and re-smooth mineral soil displaced to the edges. Subsoiling would immediately reduce the soil strength of treated acres below natural levels for the majority of the profile, from which they would gradually return to natural levels in the short term as the profile settled from snow and moisture percolation. Conditions capable of infiltrating water would be returned immediately to the treated acres, which would be set on a trajectory of recovery capable of supporting vegetation within the following growing seasons. Acres treated with the bucket rake of an excavator would also be immediately capable of infiltrating water, although the overall soil strength of the profile would take longer to return to natural conditions. Acres treated in this manner are still likely to return a productive capacity in the short term, primarily as a result of freeze/thaw mechanisms and re-smoothing of displaced mineral soil.

**Fuels Treatments:** Fuels treatments proposed under Alternative 2 include machine piling (2,007 unit acres); underburning (4,784 unit acres); mowing (2,998 unit acres); hand lop and scatter (1,209 unit acres); ladder fuels reduction (3,172 acres); pre-commercial thinning by hand (9,551 unit acres); and hand piling (3,464 unit acres). All fuels treatments would follow silvicultural stand prescriptions and result in relatively low additional impacts to the soil resource.
**Machine piling** would occur within a subset of commercially harvested units with pre-treatment fuel loadings generally greater than 16 tons per acre. Machine piling would utilize grapple machinery to reduce slash concentrations within treated units following mechanical harvest in order to meet LRMP fuel loading standards. Project design features would restrict the operation of this machinery to skid trails utilized or created by the harvest activities or single out and back passes between trails. Off trail travel over areas where excavator harvesters had previously operated to cut and accumulate material could result in detrimental compaction as a result of multiple machine passes over the same piece of ground. However, the extent of this overlap is expected to be localized and potential increases to detrimental conditions from machine piling are likely to be less than 2% of the unit area.

Project design features also restrict the location of machine piles to areas already impacted from past or proposed activities such as landings and skid trails where possible. Burning large landing piles would incur elevated ground-level heating capable of volatilizing soil nutrients and altering physical soil properties. However, impacts would be localized to the footprint of the pile and overlap detrimentally compacted soil conditions incurred by the harvest and skidding operations. The burning of smaller grapple piles would also be expected to cause localized impacts to the soil resource in areas that overlap detrimentally compacted conditions. These piles would be located on detrimentally compacted skid trails and, although they would be smaller in size than landing piles, ground-level heating would still be capable of volatilizing nutrients, albeit to a lesser degree. As a result, most detrimental conditions resulting from burning landing or grapple piles would not be additive to the totals incurred from harvest operations.

**Lop and scatter, hand thinning and hand piling** treatments are not expected to incur detrimental impacts on the soil resource. Some units would be hand thinned with chainsaws and hand piled, incurring no additional detrimental impacts to the soil from these activities. Hand piled slash would be burned and may incur localized impacts to the soil resource. The burning of hand piles is expected to cause minimal detrimental impacts to the soil resource since the piles are relatively small and loosely compressed, generating ground-level heating that is usually not elevated long enough to volatilize nutrients or detrimentally alter soil properties that affect long-term site productivity. Soil under these types of piles has been observed to be covered with the moss *Funeria hygrometrica* after the growing season following burning, indicating relatively steady recovery of these areas. Piles generated and burned in these units are likely to impact <1% of the soil resource within a treated unit as a result of elevated temperatures and heat penetration into the soil profile.

**Mowing (~2,998 acres) and mastication (~2,915 acres)** activities are proposed within a number of the proposed activity units to reduce the heights and continuity of the brush component prior to underburn prescriptions. This activity is not likely to cause detrimental soil displacement and changes in soil strength appear to be inconsequential from single pass traffic by the ASV tractor (Soil Monitoring Report, 1997). The primary factors that limit soil compaction and displacement are the low ground pressure of the tractor, the limited amount of traffic (one or two equipment passes), and the variable cushioning effect of surface organic matter.

**Prescribed fire** would be used to reduce fuel accumulations in many of the activity areas proposed for mechanical harvest and mowing or mastication (~3,335 unit acres). Detrimental impacts to the soil resource are expected to be very localized in extent under post-harvest conditions that have reduced stand densities and fuel loading within the activity areas to levels within a range receptive to the spread of low to moderate intensity fire. Planned ignitions would also occur within applicable LRMP standards and guidelines and under Best Management Practices (BMPs) included in prescribed burn plans to minimize effects to the soil resource. Prescribed burn plans would include soil moisture and duff retention guidelines to minimize the risk for intense ground-level heating and
exposure of mineral soil. It is expected that adequate retention of fine organic matter (litter and duff layer) would remain on the surface following burn operations for protecting mineral soil from erosion and supplying nutrients for vegetative and soil microbial growth.

The risk of elevated soil heating during prescribed burn operations is localized to areas underneath coarse woody debris (CWD). Although high-to-extreme fire hazard and potential for excessive soil heating exists when CWD on the surface exceeds 30 to 40 tons per acre (Brown et al., 2003), overall levels of CWD prior to the implementation of prescribed burning are expected to range from about 5 to 12 tons of per acre over most of the activity areas (Flank Fuels specialist report). Soil heating is likely to be minimal regardless of the season of burn since higher moisture levels are generally present during spring burns and fall burns would be conducted following brief periods of precipitation. Prescribed burns also incur a risk of excessive consumption of CWD present on the soil surface. This risk is relatively low since low-intensity prescribed burns do not readily consume material much larger than 3 inches in diameter, and charring does not substantially interfere with the decomposition or function of CWD (Graham et al., 1994). As a result, it is expected that there would be little or no detrimental changes in soil properties or CWD levels from prescribed burning.

Although mowing operations will add fine fuels to existing levels of natural fuel accumulations on the soil surface within some activity units, shrub heights and continuity will be reduced to minimize subsequent flame heights generated during a burn. Natural and mowed fine fuel accumulations (i.e., decadent brush, tree branches, and needle cast litter) typically do not burn for long durations or cause excessive soil heating (Maxwell, Ward, 1980). Soil heating is expected to be minimal during burn operations under the fuel type (grass, brush, trees), density, and nature of the litter and duff layers (thickness, moisture content) present at the time of ignition.

The implementation of prescribed burns would have localized direct effects to the soil resource from the construction of containment line where existing roads or fuel breaks are not present. Line would be constructed by hand or with a low-ground pressure ATV machine pulling a small wedge-shaped plow to expose mineral soil in widths of approximately 1.5 and 3 feet, respectively. Soil compaction is not a concern because this activity would be accomplished with a single equipment pass or hand tools. Although vegetative and surface organic cover would be removed from these areas the extent of soil disturbance associated with machine and hand line activities would not remove surface organic layers in large enough areas, at least 5 feet in width as defined in FSM 2520, to qualify as detrimental soil displacement. The impacts would also be mitigated to some degree by the redistribution of displaced topsoil and unburned woody debris over mechanical fire lines following prescribed burning activities. Litter from adjacent trees, coupled with the establishment of herbaceous grasses, forbs, shrubs, and tree seedlings over time would provide new sources of fine organic matter for humus development in the mineral soil on either machine or hand created lines. The extent of disturbed soil would be limited to the minimum necessary to achieve fuel management objectives and is estimated to be <1% of any one activity area.
Summary of effects from Harvest and Fuels treatment activities:

The percentages of detrimental soil conditions following implementation of project activities would increase above existing conditions in all proposed activity areas. Increases in detrimental disturbance are estimated to range from 5 to 15 percent depending on the existing level of disturbance in each activity area. Levels would increase by the largest amounts within activity areas that have low existing disturbance levels and few existing skid trails or logging facilities available for re-utilization. This would occur in units that have not had mechanical harvest since the railroad era and that currently have levels of detrimental disturbance below 10%. Most units are likely to meet the Regional guidance for the soil resource provided in FSM 2520, R-6 Supplement No. 2500-98-1 following harvest, yarding and fuels treatment activities under this decision.

Although skid trails and landings are available for re-use within most units proposed for entry, the activities proposed under Alternative 2 are likely to increase the amount of detrimental soil disturbance by an average of 5% of the unit area acreage as a result of implementing harvest and fuels treatments in units with previous entries (Craigg, 2000). Additional soil compaction would account for the majority of these impacts. Units in Appendix Table A with 15% existing detrimental soil disturbance are likely to be near or above the 20% LRMP standard for detrimental soil conditions as a result of harvest, yarding and fuels treatment activities. Some of these units may need soil restoration treatments of past impacts in order to meet LRMP standards.

Soil Restoration Treatments on Logging Facilities and Temporary Roads: Soil restoration treatments may be applied under the Alternative 2 to comply with Regional policy in order to reduce the cumulative levels of detrimental soil conditions anticipated from this project proposal. Individual activity areas with existing soil disturbance levels of 10 to 15% may need soil restoration treatments (subsoiling) to de-compact primary skid trails and landings following proposed activities in order to comply with LRMP standards SL-3 and SL-4, and Regional policy under FSM 2520 and R-6 Supplement No. 2500-98-1 for maintaining or enhancing soil productivity. Additional treatment options for improving soil quality on disturbed sites include redistributing topsoil in areas of soil displacement damage and pulling available logging slash and woody materials over the treated surface.

Under the proposed action, soil restoration treatments may be applied with a self-drafting winged subsoiler to reclaim detrimentally compacted soil on temporary roads, primary skid trails and log landings following post-harvest activities. The winged subsoiling equipment used on the Deschutes National Forest has operated with good success where rock fragments are absent on the surface and minimal within the soil profile. Soils within the project area are well suited for tillage treatments due to their naturally low bulk densities and the relative absence of rock fragments within soil profiles. These sandy-textured soils have little or no structural development within the principal root development zone (4 to 12 inches in depth) where changes in soil compaction (bulk density) are assessed according to Regional direction (FSM 2521.03). Although equipment traffic during harvest operations can decrease soil porosity on these soil materials, compacted sites can be mitigated physically by tillage with a winged subsoiler (Powers, 1999).

Subsoiling restoration treatments would also be implemented to decommission temporary roads where appropriate conditions allow for effective operations. Rehabilitation of temporary road surfaces could also utilize the bucket rake of an excavator to de-compact the surface, replace coarse woody debris to provide organic cover, and replace and re-smooth any mineral soil displaced to the edges. Approximately 29 acres of temporary road would be created and restored under this alternative.
The effects of subsoiling on the soil resource are primarily the fracturing of compaction located at various depths in the soil profile. This specialized equipment has been shown to lift and shatter compacted soil layers in greater than 90 percent of the compacted zone with one equipment pass (Craigg, 2000). Some displacement and mixing of surface organic matter can occur from these operations despite the clearance between the tool bar and the surface of the ground that generally allows smaller logging slash to pass through without building up. The process can also bring rocks located in the soil profile to the surface. However, material that is moved and mixed is not removed off site and generally does not result in detrimental soil displacement. Since the winged subsoiler produces nearly complete loosening of compacted soil layers without causing substantial displacement, subsoiling treatments are expected to reduce soil strengths below threshold values that affect productivity and set the soil resource on a path to pre-impact status within the short-term (less than 5 years) through natural recovery processes.

Although the biological significance of subsoiling is less certain, these restoration treatments likely improve subsurface habitat by restoring the soils ability to supply nutrients, moisture, and air that support soil microorganisms. Research studies on the Deschutes National Forest have shown that the distributions and composition of soil biota populations rebound back toward pre-impact conditions following subsoiling treatments on compacted skid trails and log landings (Moldenke et al., 2000).

Subsoiling would be a restoration activity intended to improve physical soil and hydrologic conditions to levels better capable of supporting trees and other vegetation. This operation directly reduces soil strengths to levels at or below natural levels present before compaction from multiple machine passes occurred. As a result of these treatments, all activity units are expected to meet the Regional guidance for the soil resource provided in FSM 2520, R-6 Supplement No. 2500-98-1 following proposed harvest, yarding and fuels treatment activities.

**Sensitive Soils**

The majority of activity areas proposed for mechanical vegetation treatments do not occur on landtypes that contain sensitive soils. Portions of proposed activity areas listed in Table_3 contain sensitive soils exceeding slopes of 30% (SRI landtype 81) where the ash soils have a high hazard rating for surface erosion when cover is lost or mineral soil disturbance occurs, and a high risk for displacement from mechanized traffic. Site-specific project design criteria restricting operation of machinery on steep slopes, as well as favoring these slopes for designated wildlife leave areas, will mitigate potentially adverse effects to soils defined as landtype 81.

<table>
<thead>
<tr>
<th>Management Concern</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil displacement on slopes &gt;30% [Landtype 81]</td>
<td>Units: 80, 492, 495, 508; (249, 509, 519, 520, 521)</td>
</tr>
<tr>
<td>Regeneration in cold air drainages [Landtype 7 and 15]</td>
<td>Units: 137,198, 199, 202, 204, 261 and 304</td>
</tr>
</tbody>
</table>

**Table_3: Localized Sensitive Soils in the Flat project area within Activity Areas proposed for Mechanical Treatments**
Portions of the planning area include soils located on flat or concave microbasins that are subject to cold air drainage capable of affecting regeneration (SRI landtype 7 and 15). However, units within these areas are not a concern for regeneration since they will remain fully stocked following thinning and salvage treatments. Unit layout, design criteria and treatment prescriptions are mitigation measures intended to avoid the need for any re-planting within areas defined by these landtypes.

**Issue Measure #2: Coarse Woody Debris (CWD) and Surface Organic Matter**

The measure for CWD and surface organic matter was evaluated qualitatively based on the probable success of implementing recommended guidelines and appropriate Best Management Practices (Chapter 2 Mitigation) that address adequate retention of these important landscape components to meet wildlife habitat objectives (see Chapter 3, Wildlife Section). A minimum amount of 5 to 10 tons per acre of CWD on ponderosa pine sites and 10 to 15 tons per acre on mixed conifer or lodgepole pine sites is recommended to ensure desirable biological benefits for maintaining soil productivity and providing habitat without creating an unacceptable fire hazard. Existing CWD on the ground would be protected from disturbance and retained on site to the extent possible. Lodgepole or ponderosa pine CWD that has fallen to the ground proximate to the time of harvest could still be sound enough for commercial utilization.

The proposed harvest activities would reduce potential sources of future CWD by whole-tree harvesting and yarding material from the site. However, thinning prescriptions will leave sufficient numbers of live trees per acre from which a few per acre could potentially become snags and/or CWD through natural mortality or windthrow. Although whole tree yarding would also move the majority of limbs and tops to the log landings, harvest activities would also recruit some finer sized CWD to the forest floor through breakage of limbs and tops during felling and skidding operations. It is expected that enough broken branches, unusable small-diameter trees, and existing CWD would likely be available after mechanical thinning activities to meet the recommended guidelines for CWD retention.

Disturbance of surface organic layers and mineral soil horizons is expected to be contained to skid trails, landing areas and portions of off trail tracks within the unit area. This extent is expected to be less than 20% of the activity unit acreage, resulting in physical soil conditions and surface organic matter levels conducive to maintaining chemical and biological productivity on site. Overall nutrient availability, mycorrhizal activity and effective ground cover are not expected to be detrimentally affected by the proposed activities.

Mowing of shrubs would cause a short term increase in the level of fine fuels on site until prescribed burn treatments consumed some portions of the mowed and existing natural fuel accumulations. Burns that occur during moist conditions help ensure adequate retention of CWD and surface organic matter since low intensity fire does not readily consume material larger than 3 inches in diameter and charring does not substantially interfere with the decomposition or function of coarse woody debris (Graham et al., 1994). Although prescribed burn treatments can produce variable mortality, these trees would be a source of CWD when they eventually fall to the ground. Depending on the rate of decay and local wind conditions, many of small-diameter trees killed by the fire could fall to the ground within the short-term (less than 5 years). Prescribed burns would also increase the short term nutrient availability in localized areas and help provide and process organic matter that supports biotic habitat for mycorrhizal fungi and microorganism populations.
Issue Measure #3: Project Design Criteria and Mitigation

The management requirements, mitigation measures, and project design elements built into Alternative 2 are all intended to avoid, minimize, or rectify adverse impacts to the soil resource from ground-disturbing management activities. These elements would be implemented during and following project activities to meet the stated objectives for protecting and maintaining soil productivity.

Operational guidelines for equipment use are included in project design elements to limit the amount of surface area covered by logging facilities and confine impacts to known locations of activity areas. These guidelines include the following: 1) Re-utilizing existing logging facilities to the extent possible; 2) Confining grapple skidders to operate on designated skid trails spaced on average of 100 feet apart except where converging at log landings; 3) Avoid equipment operations in random locations of activity areas that contain sensitive soils on steep slopes over 30 percent; and 4) minimize off trail traffic of mechanized harvesters to two or fewer passes. An additional guideline option available for minimizing impacts to the soil resource includes operating equipment over frozen ground or a sufficient amount of compacted snow.

All of these guidelines have been successfully implemented in the past to minimize detrimental impacts to the soil resource. The re-use of existing logging facilities minimizes the extent of new detrimental impacts. Designating skid trails limits the extent of detrimental soil compaction to known locations across less than 13% of the activity area. Avoidance of machine traffic on steep slopes keeps surface organic material and mineral soil in place in those areas. The short-term effects of two passes or fewer by specialized machinery off designated skid trails do not generally create a detrimental soil condition. Natural processes, such as frost heaving and freeze-thaw cycles, can offset slightly increased levels of soil compaction near the soil surface from machine tracks. Finally, the use of winter logging operations has been observed to minimize the extent of soil compaction, rutting, displacement, or loss of protective plant and litter cover within activity areas when compared to operating during moist or dry season conditions.

Additional guidelines intended to minimize potential effects to the soil resource include prescribed burn plans with moisture guidelines to minimize the potential for intense ground-level heating and adverse effects to soil properties; adequate retention of coarse woody debris and fine organic matter to assure both short-term and long-term nutrient cycling on treated sites; and avoidance of equipment operations during periods of high soil moisture.

The successful application of all management practices and guidelines would help minimize the estimated percentages of detrimental soil conditions displayed in the Flat Soils Table (Appendix A) and allow LRMP standards for soil productivity to be met without the need for restoration subsoiling in most activity units. Soil restoration treatments (subsoiling) may be needed in some activity units with elevated existing detrimental soil conditions and proposed machine harvest prescriptions, and will be implemented on all temporary roads where appropriate, an activity which is highly effective in restoring detrimentally compacted soils. Dominant soils within the project area are variably suited for tillage treatments due to the presence of bedrock and rock fragments within some soil profiles. Restoration treatments, such as subsoiling, are designed to promote maintenance or enhancement of soil quality, and are consistent with Regional policy (FSM 2520, R-6 Supplement) and LRMP interpretations of standards and guidelines SL-3 and SL-4.
All reasonable Best Management Practices (BMP’s) would be applied to minimize the effects of road systems and timber management activities on the soil resource. A variety of BMP’s are available to control erosion on roads and logging facilities. The BMP’s are tiered to the Soil and Water Conservation Practices Handbook (FSH 2509.22), which contains conservation practices that have proven effective in protecting and maintaining soil and water resource values. The Oregon Department of Forestry evaluated more than 3,000 individual practices and determined a 98 percent compliance rate for BMP implementation, with 5 percent of these practices exceeding forest practice rules (National Council for Air and Stream Improvement, 1999).

Alternative 2 – Cumulative Effects

Cumulative impacts to the soil resource are the sum total of direct and indirect effects from past and proposed activities within each activity unit. Project design criteria, LRMP management requirements and mitigation measures built into the action alternatives ensure that long-term productivity will not be impaired by the application and cumulative total of short-term management practices. Although multiple activities would occur within some of the proposed activity areas, each activity would be consistent with the Deschutes LRMP Standards and Guidelines for the soil resource and the sum total of these activities are expected to meet LRMP standards for maintaining soil productivity.

Estimates of existing and predicted levels of detrimental soil disturbance for each proposed Flat unit are summarized in Appendix A. The presence of skid trails and landing areas from past entries in the majority of proposed activity units would allow the proposed harvest activities to utilize existing infrastructure and minimize impacts to undisturbed ground. Detrimental disturbance within these units is expected to increase by approximately 5%. Units with low existing impact would see a larger increase in detrimental disturbance but would also be within the 20% LRMP standards following implementation of proposed harvest and yarding activities. Fuels treatments that overlap harvest activities would be implemented under project design criteria that minimize increases in detrimental disturbance and maintain soil productivity. Restoration treatments would be implemented within activity units exceeding acceptable LRMP standards for detrimental disturbance following the implementation of all proposed activities. As a result, the combined effects of all past, present, and reasonably foreseeable management activities would be within allowable limits set by Regional direction and LRMP standards and guidelines for protecting and maintaining soil productivity within each of the proposed activity areas.

Measure #1: Detrimental Soil Disturbance: The combined effects of existing disturbances and those anticipated from implementing the multiple activities proposed in the Flat project are summarized as cumulative within the boundary of each activity unit. Estimates of existing and predicted amounts of detrimental soil conditions are displayed in Appendix A. Existing levels of detrimental soil conditions vary from 5 to 15% within the activity areas proposed for mechanical treatments. None of the proposed activity areas currently exceed the 20% LRMP standard for detrimental soil conditions.

Under Alternative 2, ground-based logging operations would incur an increase in detrimental soil disturbance within approximately 7,319 acres of proposed activity units. As previously discussed under direct and indirect effects, the project design elements, management requirements, and Best Management Practices (BMPs) built into this alternative are all designed to avoid or minimize potentially adverse impacts to the soil resource. The amount of disturbed soil associated with logging facilities would be limited to the minimum necessary to achieve management objectives. Compliance with LRMP standard and guideline SL-5 is addressed by excluding portions of activity areas with
sensitive soils on steep slopes from machine traffic. All reasonable Best Management Practices for Timber Management and Road Systems would be applied to protect the soil surface and control erosion on, and adjacent to, roads and logging facilities used during project implementation. These conservation practices are to be implemented during and following project activities to help ensure that the stated objectives for protecting and maintaining soil productivity are met.

Estimated disturbance resulting from skid trails, landings and off trail tracks would be approximately 15% of the unit area, much of which would overlap existing detrimental soil conditions in most units. Whole tree harvest and yarding activities would localize machine piling disturbances to landing areas in most activity units, although additional traffic off of skid trails for piling would occur within units with elevated existing levels of down wood. However, the majority of machine piles would be located and burned on skid trails or landings that already have detrimentally compacted or displaced conditions resulting in a conservative addition of 2% detrimental conditions where grapple piling traffic overlapped with off trail harvester traffic.

Additional impacts from mowing or mastication operations are expected to be minimal since they would be accomplished using low ground-pressure machinery, limited passes or under restricted travel. Hand thinning, hand piling and burning of slash would cause a minimal increase in detrimental soil conditions because machinery would not be used and the burning of smaller piles would not be expected to cause severely burned soil. There would also be no cumulative effects from proposed prescribed burn treatments since they will be conducted at times and under conditions that result in low to moderate intensity burns that do not cause detrimental changes in soil properties. As a result, the cumulative effects to the soil resource within mechanical treatment units are expected to be within LRMP standards for maintaining soil productivity following harvest, skidding, and fuels activities for the majority of units. A subset of units needing machine piling may need restoration treatment of impacts from previous entries in order to meet LRMP standards for maintaining soil productivity.

Measure #2: Coarse Woody Debris (CWD) and Surface Organic Matter: As previously described for the direct and indirect effects, it is expected that Alternative 2 would meet LRMP standards for soil productivity and comply with the recommended management guidelines that ensure adequate retention of snags, coarse woody debris, and fine organic matter following both harvest and fuels treatments. The retention of these components will provide effective surface cover, substrate for biological activity (including mycorrhizae), and available nutrients to maintain soil productivity on treated sites.

Measure #3: Project Design Criteria and Mitigation: Under Alternative 2, project implementation includes the application of management requirements, project design elements and mitigation measures during and following project activities to meet stated objectives for protecting and maintaining soil productivity. Operational guidelines for equipment use provide options for limiting the amount of surface area covered by logging facilities and controlling equipment operations to locations and ground conditions that are less susceptible to detrimental soil impacts within activity areas.

Alternative 2 is not expected to create any impacts that would cause irreversible damage to soil productivity. There is no risk for mechanical disturbances to cause soil mass failures (landslides) due to the inherent stability of dominant landtypes and the lack of seasonally wet soils on steep slopes. Careful planning and the application of Best Management Practices and project design elements would be used to prevent irreversible losses of the soil resource. The development and use of temporary roads and logging facilities would incur a temporary detrimental loss of soil productivity on those areas until their functions have been served and disturbed sites are set back on a path of

25
recovery through restoration treatments. Approximately 29 acres of the soil resource will be converted to temporary roads and subsequently subsoiled.

All reasonable BMPs would be applied to minimize the effects of road systems, fuels and timber management activities on the soil resource. The BMPs are tiered to the Soil and Water Conservation Practices Handbook (FSH 2509.22), which contains conservation practices that have proven effective in protecting and maintaining soil and water resource values. Restoration treatments, such as subsoiling, are designed to promote maintenance or enhancement of soil quality, and these conservation practices are consistent with both LRMP management direction and Regional policy. Alternative 2 includes the possibility of subsoiling to improve the hydrologic function and productivity on soils that were detrimentally disturbed to create temporary roads, primary skid trails and log landings. Other rehabilitation methods include scarifying of surface compaction with the bucket of an excavator and the replacement of fine and coarse woody debris on those surfaces to promote physical and biological recovery of the soil resource.

**Alternative 3**

Alternative 3 would reduce the extent of effects to the soil resource compared to Alternative 2 as a result of excluding harvest and salvage treatments (HOR/HSV and HCR/HSV prescriptions) from approximately 313 unit acres and clearcut harvest without salvage (HCR) from approximately 146 acres. An additional 49 acres would have a shelterwood prescription (HSH) dropped in favor of a selection cut (HSL) to develop an uneven aged stand with only a slight change in effects to the soil resource.

**Direct and Indirect Effects**

**Harvest Effects:** Direct and indirect effects to the soil resource under Alternative 3 would be the same as those described for Alternative 2 within approximately 6,229 unit acres proposed for silvicultural harvest prescriptions using mechanical ground-based equipment. Effects within approximately 49 unit acres would be slightly less than those described for Alternative 2 where prescriptions were changed from shelterwood (HSH) with salvage (HSV) to a selection cut (HSL). This change would reduce the amount of material removed and in turn reduce the amount of machine traffic within the unit area.

No direct effects to the soil resource would occur under Alternative 3 within approximately 284 unit acres proposed for various harvest and salvage prescriptions under Alternative 2. These acres would remain in their current condition for existing detrimental disturbance described in the unit summary table (Appendix A). Existing and potential fuel loads within these units would not be reduced, which could indirectly affect the soil resource in both the short and long term by increasing the behavior, intensity and duration of wildfire through heavy accumulations of down woody debris. However, although these changes in fire characteristics have the potential to incur detrimental burn damage to the soil resource, it would be expected to occur over a relatively low percentage of the actual acreage. Recent wildfires across the Deschutes have generally been observed to incur detrimental burn damage over less than 5% of the actual fire acreage, primarily directly underneath down logs lying directly on the soil surface.
**Temporary Roads**: Alternative 3 would have 14.6 miles of temporary roads located in the same units as described for Alternative 2. The creation and use of these temporary roads would incur the same short term effects to the soil resource over approximately 26.5 acres of variably disturbed ground. All of these acres would be tilled with a tilth subsoiler following their use and return the soil strength to or below natural levels.

**Fuels treatment effects**: The direct and indirect effects of mechanical fuels treatments on the soil resource would remain the same as described under Alternative 2 in all units proposed for commercial silvicultural prescriptions under this alternative (approximately 6,229 unit acres).

Approximately 1,447 fewer acres would be underburned following mastication and 153 fewer acres would be underburned following mowing operations. Total treatment acres of understory fuels with mastication or mowing operations would be reduced by approximately 37 under this alternative. Approximately 170 acres of fuels only treatments would be added under this alternative, although the total amount of underburning would be reduced by approximately 1,828 acres.

**Cumulative effects – Alternative 3**

The cumulative effects to the soil resource would be expected to be the same under this alternative as those described under Alternative 3 for approximately 6,229 unit acres proposed for silvicultural harvest and fuels treatments.

**Foreseeable Actions Common to All Alternatives**

Future management activities are assumed to occur as planned in the schedule of projects for the Deschutes National Forest. No outyear timber sales are currently scheduled within the Flat planning area. No on-going fuel reduction activities are currently planned within the project area boundaries.

Future soil disturbances from recreational OHV use would be confined to relatively small areas along trail edges that have a relatively minor effect on overall site productivity. Road maintenance activities would reduce accelerated erosion rates where improvements are necessary to correct drainage problems on specific segments of existing road proposed for use as a haul route. Surface erosion can usually be controlled by implementing appropriate Best Management Practices (BMPs) that reduce the potential for indirect effects to soils in areas adjacent to roadways. The treatment of invasive species with herbicides would occur along road 22 and some other arterial or collector roads resulting in the reduction of invasive populations and improvement in soil conditions on these sites. There are no site-specific mitigation measures or post harvest activities recommended by other resource specialists that would cause additional soil impacts from ground disturbing activities. As a result, there are no major soils related concerns associated with the combined effects of these future activities. The cumulative effects from the actions proposed under Alternatives 2 and 3, combined with all past, present, and reasonably foreseeable management activities are not expected to incur detrimental soil impacts extensive enough to exceed LRMP and Region 6 standards and guidelines for maintaining soil productivity within the project area or specific activity area units. Consequently, there would be no measurable cumulative increase in the extent of detrimental soil conditions beyond the predicted levels displayed for each of the proposed activity areas in Appendix A.
Management Requirements, Project Design Criteria and Mitigation Measures

The management requirements, project design criteria and mitigation measures listed for the soil resource are to be implemented during or after the project in order to meet the stated objectives for protecting and maintaining soil productivity. In general, management requirements represent standard operating procedure for the protection of Forest resources. The source for the requirements is typically standards and guidelines from the LRMP.

Effectiveness ratings for these components provide a qualitative assessment of expected effectiveness that the implemented practice will have on preventing or reducing impacts on soil and water resources.

Effectiveness ratings of High, Moderate or Low are based on the following criteria:

a) Literature and Research
b) Administrative Studies (local or within similar ecosystem)
c) Experience (judgment of qualified personnel by education and/or experience)
d) Fact (obvious by reasoned, logical response)

**HIGH:** Practice is highly effective (greater than 90%), meets one or more of the rating criteria, and documentation is available.

**MODERATE:** Documentation shows that practice is 75 to 90 percent effective; or Logic indicates that practice is highly effective, but there is no documentation. Implementation and effectiveness of this practice needs to be monitored and the practice will be modified if necessary to achieve the mitigation objective.

**LOW:** Effectiveness is unknown or unverified, and there is little or no documentation; or applied logic is uncertain and practice is estimated to be less than 60 percent effective. This practice is speculative and needs both effectiveness and validation monitoring.

Management Requirement: Apply appropriate Best Management Practices (BMPs) to all ground-disturbing management activities, as described in General Water Quality Best Management Practices (Pacific Northwest Region, 1988). These BMPs are tiered to the Soil and Water Conservation Practices (SWCP) Handbook (FSH 2509.22), which contains conservation practices that have proven effective in protecting and maintaining soil and water resource values. The Deschutes Forest Plan states that BMPs will be selected and incorporated into project plans in accordance with the Clean Water Act for protection of waters of the State of Oregon (Forest Plan 4-69). There are no surface waters within or adjacent to the Flat planning area.

Specific BMPs commonly used to minimize the effects of road systems, fuels and timber management activities on the soil resource are briefly described for this project proposal.

- **Logging Infrastructure:** Use old landings and skidding networks whenever possible. *High effectiveness.* In all proposed activity areas, locations for new yarding and transportation systems would be designated prior to the logging operations. This includes temporary roads, spur roads, log landings, and primary (main) skid trail networks. (LRMP SL-1 & SL-3; Timber Management BMP T-11, T-14 & T-16). *Moderate effectiveness.*

- **Surface Drainage on Temporary Roads and Skid trails** – minimize the erosive effects of concentrated water through the proper design and construction of temporary roads (Road BMP R-7); Assure that water control structures are installed and maintained on skid trails that have gradients of 10
percent or more; Ensure erosion control structures are stabilized and working effectively (LRMP SL-1; Timber Management BMP T-16, T-18).  *Moderate effectiveness*

- **Road Maintenance** – conduct regular preventive maintenance to avoid deterioration of the road surface and minimize the effects of erosion and sedimentation (Road BMP R-18, R-19).  *Moderate to High effectiveness.*

- **Protect Soils and Water during prescribed burn operations** – A burn plan addressing compliance with all applicable LRMP standards and guidelines and Best Management Practices will be completed before the initiation of prescribed fire treatments in planned activity areas. Prescribed burn plans need to include soil moisture guidelines to minimize the risk of intense fire and adverse impacts to soil and water resources (LRMP SL-1 & SL-3; Timber BMP T-2, T-3 & T-13; Fuels Management BMP F-2, F-3).  *Moderate to High effectiveness.*

- **Coarse Woody Debris/Down Wood** - Assure that on Ponderosa Pine sites, a minimum of 5 to 10 tons per acre of large woody debris (greater than 3-inches in diameter) is retained within activity areas to provide organic matter reservoirs for nutrient cycling that helps maintain long-term site productivity (LRMP SL-1). Assure that on Mixed Conifer sites, a minimum of 10 to 15 tons per acre (greater than 3 inches in diameter) is retained for long-term nutrient cycling.  *Moderate effectiveness.*

- **Maintain duff layer** – Strive to maintain fine organic matter (organic materials less than 3-inches in diameter; commonly refered to as the duff layer) over at least 65 percent of an activity area (pertains to both harvesting and post-harvest operations). If the potential natural plant community (i.e., site) is not capable of producing fine organic matter over 65 percent of the area, adjust minimum amounts to reflect potential vegetation site capabilities (LRMP SL-6; Fuels Management BMP F-2; Timber Management BMP T-13).  *Moderate effectiveness.*

- **Soil and Water Protection Needs** - Use sale area maps for designating soil and water protection needs (Timber Management BMP T-4).  *Moderate effectiveness.*

**Project Design Criteria:** Project Design Criteria are specific actions that could be taken to minimize, avoid or eliminate potentially significant impacts on the resources from proposed activities. The following criteria are intended to limit the amount of surface area covered by logging facilities and minimize the extent of new soil disturbance from mechanical treatments included in project activities. Specific objectives of these criteria are to avoid or minimize potentially adverse displacement and compaction damage to soils by controlling equipment operations to locations and conditions that are less susceptible to resource damage. Options include using some or all of the following:

<table>
<thead>
<tr>
<th>Soils Project Design Criteria</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Units 27, 28, 69, 140, 156, 221, 224, 235, 321, 343 and 392</td>
<td>High</td>
</tr>
<tr>
<td>Subsoil pre-existing logging facilities to ensure that total detrimental compaction does not exceed 20% of the unit following harvest and fuels treatment activities.</td>
<td></td>
</tr>
<tr>
<td>Commercial Units</td>
<td>Moderate</td>
</tr>
<tr>
<td>Construct and maintain temporary roads to minimize the erosive effects of concentrated water during operations. Waterbar temporary roads following completion of haul activities (Road BMP R-7).</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>Include soil moisture guidelines in prescribed burn plans to minimize the risk of intense fire and adverse impacts to soil and water resources (LRMP SL-1 &amp; SL-3; Timber BMP T-2, T-3 &amp; T-13; Fuels Management BMP F-2, F-3).</td>
</tr>
<tr>
<td>All</td>
<td>Strive to maintain fine organic matter (organic materials less than 3-inches in diameter; commonly referred to as the duff layer) within each activity area during harvesting and post-harvest operations. (LRMP SL-6; Fuels Management BMP F-2; Timber Management BMP T-13).</td>
</tr>
<tr>
<td>Commercial Units</td>
<td>Use old landings and skidding networks where appropriate or designate locations for new skid trails and landings. Assure that water control structures are installed and maintained on skid trails that have gradients of 10 percent or more. Ensure erosion control structures are stabilized and working effectively (LRMP SL-1; Timber Management BMP T-16, T-18).</td>
</tr>
<tr>
<td>Commercial Units</td>
<td>In all proposed activity areas, locations for new yarding and transportation systems would be designated prior to the logging operations. This includes temporary roads, spur roads, log landings, and primary (main) skid trail networks. (LRMP SL-1 &amp; SL-3; Timber Management BMP T-11, T-14 &amp; T-16).</td>
</tr>
<tr>
<td>Commercial units</td>
<td>Maintain spacing of 100 to 150 feet for all primary (main) skid trail routes, except where converging at landings. Closer spacing due to complex terrain must be approved in advance by the Timber Sale Administrator.</td>
</tr>
<tr>
<td>Commercial units</td>
<td>Restrict grapple skidders to designated areas</td>
</tr>
<tr>
<td>Commercial units</td>
<td>Limit the amount of traffic from other specialized equipment off designated areas.</td>
</tr>
<tr>
<td>Commercial units</td>
<td>Minimize machine trips to accumulate harvested material for yarding to two or fewer passes over the same piece of ground. Harvester shears will be authorized to operate off designated skid trails at 30 foot intervals and make no more than two equipment passes on any site-specific area to accumulate materials.</td>
</tr>
<tr>
<td>Commercial units</td>
<td>Directionally bunch material along pre-approved skid trails, and suspend the leading end of trees during skidding operations.</td>
</tr>
<tr>
<td>All</td>
<td>Avoid equipment operations during times of the year when soils are extremely dry and subject to excessive soil displacement. Avoid equipment operations during periods of high soil moisture, as evidenced by equipment tracks that sink deeper than during dry or frozen conditions.</td>
</tr>
<tr>
<td>All</td>
<td>Minimize off trail traffic of ASV tractor used for felling to two or fewer passes over the same piece of ground.</td>
</tr>
<tr>
<td>Units 80, 491, 492</td>
<td>Prioritize areas of slope exceeding 30% for leave areas where present.</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Commercial units</td>
<td>Operate equipment over frozen ground or a sufficient amount of compacted snow when conditions are available to protect mineral soil. Equipment operations should be discontinued when frozen ground begins to thaw or when there is too little compacted snow and equipment begins to cause soil puddling damage (rutting).</td>
</tr>
<tr>
<td>All</td>
<td>Restrict grapple skidders to designated areas (i.e., roads, landings, designated skid trails), and limiting the amount of traffic from other specialized equipment off designated areas. Harvester shears will be authorized to operate off designated skid trails at 30 foot intervals and make no more than two equipment passes on any site-specific area to accumulate materials. (All commercial units)</td>
</tr>
<tr>
<td>All</td>
<td>Grapple pile only from existing skid trails or those created during yarding operations.</td>
</tr>
<tr>
<td>All</td>
<td>Assure that water control structures are installed and maintained on skid trails that have gradients of 10 percent or more.</td>
</tr>
<tr>
<td>Units &gt;30% 80, 491, 492 and 508</td>
<td>Restrict mechanical disturbance on slopes greater than 30 percent to designated areas (i.e., roads, landings, designated skid trails) at all times and require operators to winch logs to skidders from these areas. Hand felled trees shall be directionally felled toward pre-approved skid trails. Exceptions for areas that make up less than 10 percent of an activity area would be subject to Forest Service approval. [Forest Plan Standards and Guidelines (SL-1 and SL-3); Timber Management BMPs T-2, T-4, T-9, T-11 and T-12; Forest Service Soil and Water Conservation Practices Handbook (FSH 2509.22); Froehlich et al 1981; Clayton, 1990; Experience]</td>
</tr>
</tbody>
</table>

**Mitigation Measure:** Mitigation measures are implemented to rectify a significant impact by restoring the affected environment (40 CFR 1508.02).

**MM - Soils_1:** Decommission (obliterate) all temporary roads created for the current entry. Subsoil or utilize excavator bucket teeth to loosen compacted soils on all temporary roads. Pull slash and woody materials over treated surfaces to establish effective ground cover protection where available.


**MM - Soils_2:** Apply restoration treatments (subsoiling) to primary logging facilities in order to meet LRMP standards or reduce overall impacts.
• Units included in Appendix A with 15% existing detrimental disturbance that are proposed for machine piling and salvage prescriptions are likely to need subsoiling restoration treatments of previous impacts to meet LRMP standards for soil productivity.

Objectives: Reduce the extent of detrimentally disturbed soil to meet management objectives. Restore and stabilize detrimentally disturbed soils prior to seasonal runoff events.

Effectiveness: HIGH

Basis: Forest Plan Standards and Guidelines for Soil, Water and Riparian Resources (SL-1 and SL-4); Watershed Management BMP W-1; Cafferata, 1983; Garland, 1983; Experience, Logic.

KV Project Opportunities

Subsoil – Restoration/Enhancement_Sale Area Improvement. Approximately 24 acres of the soil resource within proposed activity areas listed in Table 3.3 (Unit #s 12, 14, 16, 20, 21, 23, 32, 33, 35, 36, 39, 47, 50, 53, 56, 59, 67 and 70) are likely to need subsoiling restoration treatments of previous impacts as a Sale Area Improvement in order to meet LRMP standards for soil productivity. These activities would be funded with KV monies or other sources, as available, as a mandatory part of the proposed actions associated with Alternatives 2 & 3. Subsoiling treatments on skid trails and log landings additional to these acres in any units receiving mechanical harvest treatments would further reduce the cumulative amount of detrimentally compacted soil and result in a net improvement in soil quality over a larger portion of the project area.

Appendix A

Flat Unit Tables

(See accompanying document)
REFERENCES

Bisby, T. 2005. Letter to the Files regarding Field Reconnaissance and average size of Grapple Piles in Unit 18 of the Pickle Timber Sale.


References (Continued)


