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Soil Report

Westside Fire Recovery

Happy Camp Oak Knoll and Salmon/Scott River Ranger Districts
Klamath National Forest, Siskiyou County, CA

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Executive Summary

This section describes the current situation and effects of the project on soil resources.

Methodology and Analysis Indicators

Analysis of the effects of individual management activities on the soil resource (soil productivity and soil ecosystem functionality) is guided by the Forest Plan Standards and Guidelines and FSM 2500, Chapter 2550, Supplement 2500-2012-1. Four indicators were chosen that address relevant issues in the Westside Fire Recovery project (project) and measure compliance with Forest Plan Standard and Guidelines. The indicators include: soil stability, surface organic matter, soil organic matter, and soil structure.

The unit measures for each indicator is acres not meeting desired conditions. Soil stability desired conditions are not met when Erosion Hazard Ratios (EHRs) are high or when soil cover is less than 30 percent.

For this project, surface organic matter is coarse wood greater than 12 inches in diameter which is either down, or standing and dead. The surface organic matter indicator is not met when this material averages less than 200 cubic feet per acre, and partially meets when it averages less than 500 cubic feet per acre.

Soil organic matter desired conditions are not met when major portions of the area have had the upper soil layer displaced or removed to a depth of 8 inches and an area large enough to affect productivity for the desired plant species (100 square feet).

Soil structure desired conditions are not met when major portions of the area have reduced infiltration and permeability capacity indicated by soil structure and macro-porosity changes. Infiltration is the process by which water on the ground surface enters the soil. Soil macro-porosity is the amount of the soil that is composed of larger pores which are important for soil water movement and gas exchange.

The projected acres not meeting desired conditions for each indicator and activity type were determined from monitoring data collected from previous salvage projects, and based on scientific research.

Spatial and Temporal Context

For all four soil indicators, the analysis area is bounded by the project activity units because this is where impacts to soil could occur. The analysis is further bounded in time by the foreseeable future period during which effects of this project can persist as detectable, significant effects. Soil cover, as it affects soil stability, can recover quickly if needle-cast is available, and grasses, forbs, and shrubs re-sprout. The temporal boundary for soil stability is five years. Soil organic matter can take a long time to rebuild after it is lost through displacement or erosion. Once compacted, soil structure can remain affected for decades. The temporal boundary for soil organic matter, surface organic matter, and soil structure is 30 years.

Affected Environment

Soils within the project area are mainly derived from metamorphic rock, granitic rock, glacial till, or ultramafic rock. A soil map can be found in appendix A of the Soil resource report and

table 4 of that report displays the proportion of general soil groups and the corresponding soil properties used in the analysis of this report.

The dominant soils within the analysis area are mostly sandy loams or loams with gravelly to extremely gravelly texture modifiers, indicating high natural infiltration rates, and high rock content in many areas. These soils range from shallow to deep, reflecting a wide range of soil productivity and soil hydrologic groups. Specific dominant soils include the Clallam, Holland, Gilligan, Deadwood, and Jayar. Compaction ratings are moderate for these soils.

The affected environment includes past actions within the project area. The 2014 wildfires have impacted soil organic matter and soil cover. The greatest impacts to soil structure have occurred on approximately 1,500 acres that have been impacted by vegetation management using heavy equipment within the last 30 years. Field monitoring results indicate that the extent of detrimentally compacted soil is minimal, yet soil cover and soil organic matter have been impacted. This indicates past forest management has had a minimal impact on detrimental soil porosity and the 2014 fires have likely overshadowed past management effects to soil cover and organic matter. The existing soil condition is most dominated by the Whites, Beaver, and Happy Camp fires that burned through the project area between July and September 2014.

Currently, approximately 500 acres of the project area are not meeting desired conditions for soil stability (see table 5 of this report). The areas that are not meeting the desired condition have high EHRs due to recent wildfires which combusted organic matter on top of the soil surface. Soil disturbance resulting in bare soil (less than 30 percent cover) generally results in high EHRs if slopes are greater than 20 percent.

The current condition is that approximately 660 acres of the project area are not meeting desired conditions for soil organic matter because they have high Soil Burn Severities (SBS). Major impacts to soil productivity have occurred in areas with moderate to high SBS. Negative impacts include destruction of the protective vegetation canopy and forest floor, a significant loss of soil carbon and nitrogen, and reduced infiltration capacity, which can lead to landslides, dry ravel (downslope movement of loose, dry particles), and erosion by wind and water causing increased runoff and sediment input into streams (Erickson 2008).

All of the project area is meeting the desired condition for surface organic matter. Although many areas of the project have less than 200 cubic feet per acre of large woody debris in contact with the soil, there is a high volume of standing dead trees, greater than 12 inch diameter. These would contribute organic material to the soil surface within the next several years and would eventually be cycled into the soil to provide for plant growth.

It is estimated less than 20 acres of the project area are not meeting desired conditions for soil structure because severe soil compaction was measured on 2 percent of the soil plots monitored and approximately 1,500 acres have been impacted by harvest equipment during the last 30 years. Within the project area, soil textures of sandy loam and loam produce moderate compaction ratings (table 2 of the Soil resource report).

Environmental Consequences

Alternative 1

Direct Effects and Indirect Effects

Immediately following the 2014 fires, EHRs were high on approximately 57 percent of the project area. Within one year following the fire, soil cover would increase on areas with low to moderate soil burn severities. Soil cover is less likely to increase on areas with high SBS because tree canopy has been consumed. Therefore, areas with high EHRs would decrease to moderate, except where there is high SBS on approximately 490 acres. These areas would not meet the desired condition for soil stability. Based on field data collected, it is estimated that soil cover is less than 30 percent on this same area. Effective soil cover will only be fully reestablished after surface vegetation recovers. This will expose the soil to higher erosion potential over the next 3 to 6 years (Berg and Azuma 2010).

Under alternative 1, large surface organic matter could reach sufficient levels within approximately five years and contribute to the recovery of soil productivity. It is possible that the surface organic matter indicator would not be met if material greater than 12 inch diameter exceeds 800 cubic feet. If a wildfire occurs during the next 10 to 15 years, soils would burn with a high SBS directly beneath this large woody debris. This could occur on approximately 2,500 acres of the project area and it’s estimated large wood could cover 5 to 10 percent of this area.

Soil organic matter will remain intact unless severe storm events result in the loss of large amounts of topsoil. Soil structure conditions will remain the same in the short term, with very slow long-term natural recovery of old skid trails and landings.

Cumulative Effects

Grazing is the only reasonably foreseeable future action that would occur within the same area as this project. Although minimal amounts of grazing activities are ongoing within allotments found within the project area, most of the project activities are proposed on steeper slopes which cattle use rarely, if ever, or are largely transitory in nature. Further, annual operating instructions provided to permittees will limit permitted grazing activities as needed to minimize impacts, not only to rangeland health but also to soil conditions (see range section of this chapter and the Rangeland resource report). For these reasons, no measurable cumulative impacts to soil indicators are anticipated as a result of ongoing grazing activities when added to the activities proposed with this project.

Wildfire and forest management are an ongoing impact to soil stability, surface organic matter, soil organic matter and soil structure. The effects from the 2014 wildfires overwhelm effects from past management practices. The cumulative effects for alternative 1 would be a continued increase in soil stability due to falling needles, branches, and eventually tree boles. This would result in decreased EHRs and a gradual increase in soil organic matter as material decomposes. These processes would encourage the return of vegetation which would further increase soil cover and eventually soil organic matter. Soil organic matter would reach desired conditions more slowly in areas with high SBS, and recovery could take several decades to a century. Surface organic matter would be expected to reach desired conditions within approximately 10

years. Damage to soil structure would continue to ameliorate, yet this process occurs slowly. The most compacted areas could take approximately 30 years to reach desired condition.

The natural falling of dead needles, branches, and eventually tree boles would continue to assist in the recovery of soil stability. Larger surface organic matter would be added from the falling of tree boles over the next 5 to 10 years to meet the surface organic matter indicator. The surface organic matter indicator may not be met if a wildfire occurs during the next 10 to 15 years, resulting in high SBS directly beneath large woody material in contact with the soil. Soil organic matter will remain intact unless severe storm events result in the loss of large amounts of topsoil. Soil structure conditions will remain the same in the short term, with very slow long-term natural recovery of old skid trails and landings.

Soil indicators would not be met on approximately 660 acres for alternative 1. This occurs mainly where soils burned with high SBS and soil stability and soil organic material (SOM) have been impacted.

Alternative 2

Direct Effects and Indirect Effects

On approximately 2,000 acres, soil stability and SOM would be impacted with most disturbances on temporary roads, landings, and skid trails. Construction of new temporary roads, associated with ground based harvest, would have the highest impact to soil stability and sedimentation (Rice et al. 1972). Newly constructed roads are the largest source of erosion and this is exacerbated in a burned environment because the capacity of the landscape to moderate flow and trap sediment is greatly reduced (Peterson et al. 2009). Project design features would require subsoiling 60 percent of new temporary roads and landings, and would require maintaining at least 50 percent effective soil cover. If soil cover is not available, soil stability and SOM could be impacted over the long term. Subsoiling would promote the recovery of soil stability, SOM, and soil structure yet soil productivity would remain impacted over the long term on compacted surfaces that are not subsoiled. This includes skid trails, existing or previously decommissioned temporary roads, and existing landings. Soil structure would be impacted on approximately 15 percent of ground-based harvest and less than 1 percent of helicopter and skyline.

During harvest, felling of dead trees would increase soil cover approximately 10 to 20 percent. Ground based skidding would remove soil cover and impact SOM on approximately 30 percent, 10 percent of skyline, and less than 1 percent of helicopter. Post fire accelerated erosion due to ground based salvage logging could result in a 6 to 1,000 fold increase in sediment production (Wagenbrenner 2015). This would mainly occur due to reduced infiltration on skid trails and other areas disturbed by ground based equipment, which would concentrate runoff as rill erosion. Where skidding occurs through areas with less than 50 percent soil cover, a project design feature would require applying at least 50 percent soil cover on skid trails greater than 15 percent slope. This could limit accelerated erosion on areas with higher EHRs.

Reductions in large woody material could lessen impacts to SOM if a wildfire occurs 10 to 15 years from now. Fuels specialist collected plot data which indicates reductions of large woody material could lessen impacts on approximately one third of the harvested area.

Vegetation recovery and subsequent ground cover could lag behind undisturbed areas by three years or more (Robichaud 2011). Seedlings that germinate following a wildfire may be damaged

or killed by mechanical disturbance associate with subsequent salvage logging (Van Nieuwstadt 2001). Areas most heavily impacted such as landings and main skid trails would be the slowest to recover. Ground-based harvest would be expected to delay vegetation recovery on up to 30 percent of a units area, and ground based harvest of roadside hazard could impact 30 to 60 percent. Vegetation began to recover almost immediately following the fires and will continue to add soil cover and increase soil stability where undisturbed.

Site preparation or fuels management zones could result in impacts to soil cover, soil organic matter and soil structure, especially if mechanical equipment is used. A project design feature would require site preparation treatments to be designed to meet the Forest Plan soil management direction. Site preparation and tree planting could benefit soil stability and SOM if brush fields, which are less effective soil cover, would otherwise dominate the site over the long term.

Proposed underburning would have minimal impacts to soil stability. The greatest impacts would occur due to line construction activities where dozers are used to re-scrape control lines to mineral soil.

Proposed legacy site treatments would be designed to improve soil stability over the long term. Minor, localized impacts to soil stability and SOM could occur due to culvert replacements and road maintenance, yet implementation of best management practices would maintain soil cover on disturbed areas. Road maintenance would have a beneficial impact to soil stability by improving drainage and decreasing the potential for rill and gully erosion. Likewise, culvert upgrades would decrease the diversion potential of drainages and resulting accelerated erosion.

For alternative 2, 2,800 acres would not meet desired conditions for soil stability, 825 would not meet surface organic matter, 2,214 acres for SOM, and 1,255 for soil structure.

Cumulative Effects

Adding the effects of alterative 2 to the effects of past, present, and reasonably foreseeable future actions could have substantial negative effects on soil desired conditions. Past effects due to forest management and the 2014 fires have been considered and discussed in the affected environment and the effects to soil stability, surface organic matter, soil organic matter and soil structure addressed there. Impacts to soil structure would occur on 70 acres proposed for ground-based harvest where harvest has occurred in the past 10 years.

Effects from grazing are as discussed under alternative 1. Adding these effects to the effects of alternative 2 will not result in measurable cumulative effects. On approximately 2,800 acres, soil indicators would not be met. This is an increase of approximately 2,300 acres compared to alternative 1. The number of acres that do not meet desired conditions for soil structure, soil organic matter, and soil structure is reduced to the extent possible with project design features.

Soil stability and SOM would be impacted most due to disturbance on temporary roads and landings. During harvest, felling of dead trees would increase soil cover approximately 10 to 20 percent. Ground based skidding would then remove soil cover and impact SOM on approximately 30 percent, 10 percent of skyline, and less than 1 percent of helicopter. Soil structure would not meet desired conditions on approximately 1,255 acres, mainly on new temporary roads, landings, and skid trails. Site preparation or fuels management zones could result in impacts to soil indicators, especially if mechanical equipment is used. Site preparation

and tree planting could benefit soil stability and SOM if brush fields, which are less effective as soil cover, would otherwise dominate the site over the long term.

Alternative 3

Direct Effects and Indirect Effects

Alternative 3 would propose approximately 480 fewer acres of ground-based harvest, 250 fewer acres of helicopter and 310 fewer acres of skyline harvest than alternative 2therefore, fewer acres would be impacted by ground-based mechanical equipment.

Alternative 3 proposes 1,215 fewer acres of fuel management zone treatments. This would decrease the area that would not meet desired soil conditions by approximately 100 acres because less soil cover would be removed due to use of mechanical equipment and removal of vegetation providing soil cover.

Under alternative 3, mechanical equipment would remove soil cover on approximately 940 acres in addition to 495 acres that would have high EHRs in alternative 1; a total of approximately 1,435 acres of the project area would not meet desired conditions for soil stability (see table 5 in the Soil resource report).

Reductions in large woody material could lessen impacts to SOM if a wildfire occurs 10 to 15 years from now. Fuels specialist collected plot data which indicates reductions of large woody material could lessen impacts on approximately one third of the harvested area.

For alternative 3, 2,380 acres would not meet desired conditions for soil stability, 560 would not meet surface organic matter, 1,980 acres for SOM, and 1,085 for soil structure.

Cumulative Effects

The cumulative effects of alternative 3 would be very similar to alternative 2. Adding the effects of alterative 3 to the effects of past, present, and reasonably foreseeable future actions could have measurable negative effects on soil desired conditions. The highest cumulative impacts to soil stability and surface organic matter would occur when mechanical equipment is used on soil that burned with a high SBS. Project design features have been developed to maintain soil cover and restrict additional use of mechanical equipment when desired conditions are most likely not met.

On approximately 2,400 acres, soil indicators would not be met. This is an increase of approximately 1,900 acres compared to alternative 1. The number of acres that do not meet desired conditions for soil structure, soil organic matter, and soil structure is reduced to the extent possible with project design features.

Alternative 4

Direct Effects and Indirect Effects

Alternative 4 would propose approximately 70 fewer acres of ground-based harvest, 560 fewer acres of skyline and 290 fewer acres of helicopter than in alternative 2; therefore, fewer acres would be affected by mechanical equipment. In addition, 2.4 miles less temporary roads would

be constructed, 15.8 miles less existing and previously decommissioned roads would be used, 10 fewer existing landings would be used, and 40 fewer new landings would be constructed.

The decreased use of landings would result in the greatest decrease, approximately 50 acres, of area not meeting the soil stability indicator. Less ground-based harvest would result in approximately 30 fewer acres where soil stability is not met, and 16 fewer acres because less temporary roads would be used or constructed.

Under alternative 4, mechanical equipment would remove soil cover on approximately 1,450 acres and, in addition to 495 acres which would have high EHRs under alternative 1, a total of approximately 1,945 acres of the project area would not meet desired conditions for soil stability (see table 5 of the Soil resource report). This is 360 fewer acres compared to alternative 2.

Alternative 4 proposes to harvest fewer ground-based and skyline units. Therefore, approximately 440 acres would not meet the surface organic matter indicator which is 390 fewer acres compared to alternative 2.

Fewer acres proposed for ground based harvest, and fuel management zone treatments would result in less impact to SOM because less area would be impacted by mechanical equipment. It's estimated approximately 1,450 acres would not meet desired conditions for SOM under alternative 3. This is a decrease of 530 acres compared to alternative 2. Fewer acres of proposed ground based harvest and fuel management zone treatment would decrease impacts to soil stability and SOM. Fewer temporary roads and landings would reduce impacts to soil stability, SOM, and soil structure. Site preparation and tree planting could benefit soil stability and SOM if brush fields, which are less effective as soil cover, would otherwise dominate the site over the long term.

Reductions in large woody material could lessen impacts to SOM if a wildfire occurs 10 to 15 years from now. Fuels specialist collected plot data which indicates reductions of large woody material could lessen impacts on approximately one third of the harvested area.

For Alternative 4, 2,415 acres would not meet desired conditions for soil stability, 440 would not meet surface organic matter, 1,690 acres for SOM, and 1,090 for soil structure.

Cumulative Effects

The cumulative effects of alternative 4 would be very similar to alternative 2. Adding the effects of alterative 4 to the effects of past, present, and reasonably foreseeable future actions could have measurable negative effects on soil desired conditions.

On approximately 2,400 acres, soil indicators would not be met. This is an increase of approximately 1,900 acres compared to alternative 1. The number of acres that do not meet desired conditions for soil structure, soil organic matter, and soil structure is reduced to the extent possible with project design features.

Alternative 5

Direct Effects and Indirect Effects

Alternative 5 would propose approximately 290 fewer acres of ground-based harvest, 2,780 fewer acres of skyline and 1,840 fewer acres of helicopter compared to alternative 2; therefore,

fewer impacts would occur due to mechanical equipment. In addition, 29 fewer existing landings would be used, and 18 fewer new landings would be constructed.

Reductions in large woody material could lessen impacts to SOM if a wildfire occurs 10 to 15 years from now. Fuels specialist collected plot data which indicates reductions of large woody material could lessen impacts on approximately one third of the harvested area.

Less ground-based harvest would result in the greatest decrease, approximately 125 acres, of area not meeting the soil stability, SOM, and soil structure indicator. Fewer landings used would result in approximately 115 fewer acres where these indicators would not be met. Site preparation and tree planting could benefit soil stability and SOM if brush fields, which are less effective as soil cover, would otherwise dominate the site over the long term.

Fewer acres proposed for ground-based harvest would result in less compaction. It's estimated alternative 5 would result in approximately 370 acres with reduced infiltration which is 650 acres less than alternative 2.

Cumulative Effects

The cumulative effects of alternative 5 would be very similar to alternative 2. Adding the effects of alterative 5 to the effects of past, present, and reasonably foreseeable future actions could have measurable negative effects on soil desired conditions.

On approximately 1,600 acres, soil indicators would not be met. This is an increase of approximately 1,100 acres compared to alternative 1. The number of acres that do not meet desired conditions for soil structure, soil organic matter, and soil structure is reduced to the extent possible with project design features.

Compliance with law, regulation, policy, and the Forest Plan

Although soil indicators would not be met on about 4,000 acres, this is less than 10 percent of the project area. Therefore, Forest Plan Standard and Guidelines 3-1 and 3-2 would be met at the project scale. A forest consistency checklist has been completed that reviews the soil standards and guidelines. Forest Plan Standard and Guidelines 3-3 through 3-6 would be met because project activities are not expected to result in major decreases to surface organic matter and soil organic matter. Forest Plan Standard and Guideline 3-7 has been met by the selection of soil plots where soils were field verified.

Soil Resource Report

Introduction

Analysis of the effects of individual management activities on the soil resource (soil productivity and soil ecosystem functionality) is guided by the Klamath National Land and Resource Management Plan Standards and Guidelines and Forest Service Manual 2500, Chapter 2550, Supplement 2500-2012-1. Soil productivity is the inherent capacity of a soil to support appropriate site-specific biological resource management objectives, which includes the growth of specified plants, plant communities, or a sequence of plant communities to support multiple land uses (USDA 2010). The soil stores water, nutrients, and provides favorable habitat for soil organisms which cycle nutrients. Chemical, physical, and biological soil processes sustain plant growth which provides forage, fiber, wildlife habitat, and protective cover for watershed protection (USDA 2012a).

For this soil analysis, Forest Service staff have developed soil quality functions and indicators that are appropriate for the proposed activities, site conditions, and soil characteristics of the project area. Soil quality functions analyzed include: support for plant growth function (soil productivity) and soil hydrologic function. Four indicators were chosen that address relevant issues in the Westside Fire Recovery project and measure compliance with Forest Plan Standard and Guidelines. The indicators include: soil stability, surface organic matter, soil organic matter, and soil structure.

For a detailed description of the alternatives considered for analysis and project design features, see Chapter 2 of the Westside Fire Recovery Project.

Methodology

A unit selection strategy was used to determine where site-specific data should be collected. Selection was based on soil sensitivity and type of management activities planned. Soils with higher erosion hazard ratings (EHRs), higher soil burn severities and areas with evidence of previous disturbance received a high priority for field review. Units proposed for ground-based commercial harvest have the highest probability of impacting the soil resource and these units were a high priority for field review. Site and soil data was collected from plots while making two to three traverses across each unit. Soil cover, soil burn severity, erosion, and evidence of previous disturbance were noted. The level of soil disturbance was estimated for each soil disturbance type. Soil data noted in the field included shallow soil areas, rock outcrop, areas of surface rock, rock lithology and general soil depth. Existing soil survey information (Foster and Lang, 1994) was used unless field investigation revealed significant differences between mapped soils and the actual site-specific soils.

Analysis Indicators

Four indicators were chosen to analyze the soil quality functions of support for plant growth (soil productivity) and soil hydrologic function. Indicators have been chosen to address relevant issues in the Westside Fire Recovery Project and measure compliance with Forest Plan Standard and Guidelines. These indicators include: soil stability, surface organic matter, soil organic matter,

and soil structure. Table 1 describes the qualitative range of conditions for these indicators and the soil quality function measured.

Table 1: Indicator Condition Assessment

Indicators	Soil Function	Indicator Conditions		
		Good **Meets Desired Condition**	**Fair** **Partially Meets Desired Condition**	**Poor** **Does Not Meet Desired Condition**
Soil Stability	Support for Plant Growth and Soil Hydrologic Functions	An adequate level of soil cover is present and signs of erosion are not visible or very limited in degree and extent. Any existing erosion control measures are effective. Generally soil cover level is 50% or greater and is well distributed for soil types capable of supporting this level.	For minor portions of the area, soil cover is lacking and/or existing erosion control measures are ineffective and there are signs of erosion such as pedestals, sheet, rill, and/or gully erosion visible.	Major portions of the area lack soil cover and/or lack effective erosion control measures. Signs of erosion such as pedestals, sheet, rill, and/or gully erosion are common.
Surface Organic Matter	Support for Plant Growth	Throughout the area, the size, amount and distribution of organic matter present is within the range of the ecological type and normal fire return interval.	For minor portions of the area, the size, amount or distribution of organic matter does not meet the desired condition. The departure can either be a deficiency or excess.	Major portions of the area do not meet the desired condition. The departure can either be a deficiency or excess.
Soil Organic Matter (SOM)	Support for Plant Growth	The thickness and color of the upper soil layer is within the normal range of characteristics for the site and is distributed normally across the area. Localized areas of displacement may have occurred but it will not affect the productivity for the desired plant species.	For minor portions of the area, the upper soil layer has been displaced or removed to a depth and area large enough to affect productivity for the desired plant species. Generally an area will be considered displaced if more than one-half of the upper soil layer or 4 inches (whichever is less) is removed from a contiguous area larger than 100 feet squared.	Major portions of the area have had the upper soil layer (8 inches) displaced or removed to a depth and area large enough to affect productivity for the desired plant species.
Soil Structure	Soil Hydrologic Function	Visually soil structure and macro-porosity (defined here as pores 1mm or larger) are relatively unchanged from natural condition for nearly all the area. Signs of erosion or overland flow are absent or very limited in degree and extent. Infiltration and permeability capacity of the soil is sufficient for the local climate.	For minor portions of the area: soil structure and macro-porosity are changed; or platy structure and/or increased density evident; or overland flow and signs of erosion are visible. Infiltration and permeability capacity is insufficient in localized portions of the area.	Major portions of the area have reduced infiltration and permeability capacity indicated by soil structure and macro-porosity changes; or platy structure and/or increased density; or signs of overland flow and erosion.

The unit measures for each indicator is acres not meeting desired conditions. Soil stability desired conditions are not met when EHRs are high or when soil cover is less than 30 percent.

For this project, surface organic matter is coarse wood greater than 12 inches in diameter which is either down, or standing and dead. The surface organic matter indicator is not met when this

material averages less than 200 cubic feet per acre, and partially meets when it averages less than 500 cubic feet per acre.

Soil organic matter desired conditions are not met when major portions of the area have had the upper soil layer displaced or removed to a depth of 8 inches and an area large enough to affect productivity for the desired plant species (100 square feet).

Soil structure desired conditions are not met when major portions of the area have reduced infiltration and permeability capacity indicated by soil structure and macro-porosity changes. Infiltration is the process by which water on the ground surface enters the soil. Soil macro-porosity is the amount of the soil that is composed of larger pores which are important for soil water movement and gas exchange. The methodology for assessing indicator condition is described in the analysis indicators section below.

Soil Stability: Soil Productivity and Soil Hydrologic Function

An adequate level of soil cover is needed to maintain soil stability and prevent accelerated erosion. Effective soil cover consists of low growing live vegetation (12 inches high), rock fragments (greater than ½ inch in diameter), slash (any size), and fine organic matter (charred or not) that is in contact with the soil surface. Fine organic matter refers to the duff, litter, and twigs less than three inches in diameter. Effective soil cover is the most important soil property in maintaining soil stability and reducing erosion. Surface cover mitigates erosion primarily by intercepting and reducing the detachment energy of raindrops, improving soil porosity, preventing soil sealing, and increasing surface roughness to slow and filter runoff (Larsen *et. al.* 2009). The percent bare soil is an important control on sediment production following timber salvage (Chase 2006). The presence of even a thin litter layer can substantially reduce soil erosion (Peterson 2009).

The soil stability indicator is not met when EHRs are high or when soil cover is less than 30 percent. The soil stability indicator is considered met when EHRs are low to moderate, or when soil cover exceeds guidelines established in the Klamath NF LMP (Table 2). Between August and November 2014, soil scientists Joe Blanchard and Nikos Hunner measured soil cover on 11 units within the project area.

Table 2: Soil Cover Guidelines for Vegetation and Fuels Management Projects (USDA, 2010)

Soil Cover Guidelines for Projects		
Soil Texture Class	**Slope (%)**	**Minimum Total Soil Cover* (%)**
Guidelines for Projects Using Tractors:		
Sandy loam or coarser	0-25	70
	26-35	80
Loam or finer	0-35	70
Guidelines for Prescribed Burning Projects:		
Sandy loam or coarser	0-25	60
	26-45	70
	46	80
Loam or finer	0-35	50
	36-60	60
	61	70

Erosion hazard rating

The Erosion Hazard Rating (EHR) system is a relative measure of the soils' sensitivity to erosion processes. Burned Area Reflectance Classification (BARC) values were used to quantify soil cover which is one of the factors used to calculate EHR. BARC imagery quantifies above ground effects of the fire and is a fairly accurate tool for measuring soil cover. For each of the three fire areas, BARC maps were created by the Remote Sensing Applications Center (RSAC, Salt Lake City, Utah) using satellite imagery and standard pre-post differential processing methods.

On thirty-five project area units, BAER soil scientists measured soil cover and found they generally corresponded to BARC values. BARC values of unburned corresponded to (71-90%) soil cover, low (31-50%), moderate (11-30%), and severe (0-10%). In addition, BAER soil scientists field validated soil texture as mapped in the Klamath Soil Survey and used this data to calculate EHR factors of Water Movement, and Texture. Digital Elevation Model (DEM) data was used to quantify slopes for EHR calculations (USDA Forest Service, 2015).

Surface Organic Matter: Support for Plant Growth

Surface organic matter is organic material on top of the mineral soil and may range in size from needles and twigs, to coarser materials such as branches and logs. These materials are major sources of ecosystem nutrients, such as nitrogen, which is essential for plant growth.

The surface organic matter indicator is met when large wood is available for long term soil productivity. The size, amount, and distribution of organic matter maintained on the mineral soil on a long term basis should be consistent with the amounts that occur given the local ecological type, climate, and normal fire return interval for the area.

The metric used to measure the soil organic matter indicator is volume of coarse wood greater than 12 inch in diameter which is either down, or standing and dead. The indicator is fully met when there is at least 500 cubic feet per acre, partially met when there is at least 200 cubic feet per acre, and not met when there is less than 200 cubic feet per acre. In addition, the surface organic matter indicator would not be met if coarse wood greater than 12 inch in diameter exceeds 800 cubic feet per acre. At this level, severe soil heating could occur beneath this material if a wildfire burns within 10 to 15 years from now.

Soil Organic Matter: Soil Hydrologic Function

Soil organic matter, also known as soil humus, is the highly decomposed organic material that is incorporated into the mineral portions of the soil. Soil organic matter is important for holding soil water, cycling nutrients, and reducing soil strength.

Impacts to soil organic matter generally come from both excessive soil heating and soil displacement from mechanical disturbances. Soil heating volatizes both the complex organic compounds and plant nutrients. Changes in the soil organic matter can affect soil nutrient cycling, water holding capacity and aggregate stability.

Soil organic matter desired conditions are not met when major portions of the area have had the upper soil layer displaced or removed to a depth of 8 inches and an area large enough to affect productivity for the desired plant species (100 square feet).

The soil organic matter (SOM) indicator is measured by the extent of soil depleted either by volatilization from fire or displaced by project activities. Assumptions are made regarding potential displacement by project activities based on research and monitoring of similar proposed actions. Soil burn severity is a measure of changes to soil properties, such as soil organic matter, caused by heat penetration below ground. High soil burn severity usually indicates penetration of heat into the soil and the consumption of fine roots and soil organic matter. Areas with high soil burn severity ratings do not meet the soil organic matter indicator. Areas displaced from previous disturbance or areas likely to be displaced from proposed activities do not meet desired conditions for soil organic matter.

Soil Structure: Soil Hydrologic Function

Soil structure desired conditions are not met when major portions of the area have reduced infiltration and permeability capacity indicated by changes to soil structure and macro-porosity. Infiltration is the process by which water on the ground surface enters the soil. Soil macro-porosity is the amount of the soil that is composed of larger pores which are important for soil water movement and gas exchange.

Soil porosity is the volume of pores in a soil that can be occupied by air, gas, or water and varies depending on the size and distribution of the particles and their arrangement with respect to each other. The two primary mechanisms for reducing soil porosity are compaction and soil sealing. The use of heavy forestry equipment and frequent stand entries increases bulk density and decreases the porosity of soils, which increases the potential for detrimental compaction (Powers et al 2005). Soil sealing is the process after a fire where fine soil particles fill the soil pores and reduce the flow of water through the voids.

The degree and extent of susceptibility to compaction is primarily influenced by soil texture, soil moisture, coarse fragments, depth of surface organic matter, ground pressure weight of the equipment, and whether the load is applied in a static or dynamic fashion. Recent research suggests that the effect of severe compaction on biomass productivity is highly dependent upon soil texture (Powers et al 2005). Soil compaction and increased soil strength can slow plant growth, impede root development, restrict water infiltration and percolation, and increase overland flow during high precipitation events, and can cause plant nutrients to be relatively immobile or inaccessible (Poff, 1996).

The compaction risk rating scheme is intended to help determine the general susceptibility to loss of soil productivity from heavy equipment operation. It is based upon the soil texture and rock content. It presumes the soil is at field capacity or at a moisture level at which it is most susceptible to soil density increase under heavy equipment operation (USDA, 2006).

A slight rating indicates that the soil is subject to little or no compaction, moderate indicates that compaction is likely between 4 to 12 inches deep, and high indicates that increased compaction would occur greater than 12 inches deep and would result in losses to productivity.

Table 3: Compaction Risk Rating

Coarse Fragment Content by Volume	Soil Texture	Hazard Rating
Fragmental (> 70%)	Any Texture	Low
Skeletal (35 - 70%)	Sandy	Low
Skeletal (35 - 70%)	Loamy	Moderate
Skeletal (35 - 70%)	Clayey	High
< 35%	Sandy	Low
< 35%	Loamy	Moderate
< 35%	Silty	High
< 35%	Clayey	High

The extent of detrimental soil compaction should not be of a size or pattern that will result in a significant change in production potential and should not result in common occurrences of overland flow and erosion within treated units (indicating that the infiltration and permeability capacity of the soil has been exceeded for the local climate).

The metric used to measure the soil structure indicator is the area with platy structure and/or increased density; or signs of overland flow and erosion. This is considered detrimental compaction and where occurs due to previous disturbance would not meet desired conditions for soil structure.

Spatial and Temporal Bounding of Analysis Area

For all four soil indicators, the analysis area is bounded by the project activity units, where soil-disturbing activities can take place. The analysis is further bounded in time by the foreseeable future period during which effects of this project can persist as detectable, significant effects. Soil cover, as it affects soil stability, can recover quickly if needle-cast is available, and grasses, forbs, and shrubs re-sprout. The temporal boundary for soil stability is five years. Soil organic matter can take a long time to rebuild after it is lost through displacement or erosion. Once compacted, soil structure can remain affected for decades. The temporal boundary for soil organic matter, surface organic matter, and soil structure is 30 years.

Affected Environment

Soils within the project area are mainly derived from metamorphic rock, granitic rock, glacial till, or ultramafic rock. A soil map can be found in Appendix A and Table 4 displays the proportion of general soil groups and the corresponding soil properties used in the analysis of this report.

The dominant soils within the analysis area are mostly sandy loams or loams with gravelly to extremely gravelly texture modifiers, indicating high natural infiltration rates, and high rock content in many areas. These soils range from shallow to deep, reflecting a wide range of soil productivity and soil hydrologic groups. Specific dominant soils include the Clallam, Holland, Gilligan, Deadwood, and Jayar. Compaction ratings are moderate for these soils.

Table 4. Soil families and associated properties used in analysis

Family	Acres	Soil Properties used in Analysis		
		Surface Texture	Soil Depth, inches	Compaction Hazard
Beaughton	163	Gravelly loam	10-20	Moderate
Blusprin	110	Verry cobbly loam	20-40	Moderate
Buell	11	Gravelly loam	60+	Moderate
Chawanakee	1095	Coarse sandy loam	<20	Moderate
Clallam	15,845	Gr ashy sandy loam	40-60	Moderate
Coboc	1,086	Gravelly loam	40-60	Moderate
Deadwood	3,023	Gr sandy loam	<20	Moderate
Dubakella	420	Stony loam	20-40	Moderate
Endlich	38	Very stony loam	20-40	Moderate
Entic Xerumbrepts	217	Gravelly loam	<20	Moderate
Gerle	433	Sandy loam	40-60	Moderate
Gilligan	3,644	Ashy silt loam	40-60+	Moderate
Goldridge	1,811	Fine sandy loam	60-80+	Moderate
Holland	4,989	Sandy loam	60+	Moderate
Jayar	3,434	V gr loam	<30	Moderate
Kang	272	Gravelly sandy clay loam	20-40	Moderate
Lithic Haploxeralfs	510	Loam	<20	Moderate
Lithic Ruptic	590	V gr loam	<20	Moderate
Nanny	134	Gravelly loam	30-60	Moderate
Olete	706	V gr silt loam	<20	Moderate
Parks	345	v gr sandy clay loam	40-60	Moderate
Rock	363	----------	-------	Low
Skalan	1,723	Gr ashy loam	<30	Moderate
Typic Haploxerolls	34	Gr Loam	20-40	Moderate
Weitchpec	393	Gravelly sandy loam	20-40	Moderate
Woodseye	2,612	V gr sandy loam	<20	Moderate

The affected environment includes past actions within the project area. The 2014 wildfires have impacted soil organic matter and soil cover. The greatest impacts to soil structure have occurred on approximately 1,500 acres that have been impacted by vegetation management using heavy equipment within the last 30 years. Field monitoring results indicate that the extent of detrimentally compacted soil is minimal, yet soil cover and soil organic matter have been impacted. This indicates past forest management has had a minimal impact on detrimental soil porosity and the 2014 fires have likely overshadowed past management effects to soil cover and organic matter. The existing soil condition is most dominated by the Whites, Beaver, and Happy Camp fires that burned through the project area between July and September 2014.

Fire can have both beneficial and negative effects on the soil resources. Fires that burn with low severity can maintain soil cover, mineralize important nutrients from plant matter stored on the soils surface, reduce fuel loads that if allowed to accumulate could cause high burn severity to the soil, and stimulate herbaceous vegetation which helps facilitate nutrient cycling. Moderate to high severity fires can cause a loss of soil hydrologic function by sealing pores and degrading soil structure, it can cause a loss of soil productivity by processes of erosion, mass-wasting, and nutrient volatization, and it can allow exotic plants to establish which can impact soil productivity.

Soil Stability

Currently, approximately 490 acres of the project area are not meeting desired conditions for soil stability (see table 5). The areas that are not meeting the desired condition have high EHRs, or less than 30 percent soil cover due to recent wildfires which combusted organic matter on top of the soil surface. Generally, existing EHRs are high on slopes greater than 30 percent and moderate on slopes less than 20 percent. Soil disturbance has the potential to increase the erosion hazard because soil cover is reduced on portions of units.

Indicator	Met	Partially met	Not met
1. Acres not meeting desired conditions for soil stability	4,076	13,858	490
2. Acres not meeting desired conditions for surface matter	40,758	0	0
3. Acres not meeting desired conditions for soil organic matter	40,098	0	660
4. Acres not meeting desired conditions for soil structure	36,682	3,261	815

Soil Organic Matter

The current condition is that approximately 660 acres of the project area are not meeting desired conditions for soil organic matter because they have high Soil Burn Severities (SBS).

The direct effect fires have on soils is measured by the SBS. Whereas fire intensity measures the changes to the vegetation community, SBS indicates both changes to the above ground material that provides both existing and future soil cover and the effects to the soil properties caused by heat penetration below ground.

SBS categories are summarized as follows (Parsons et al., 2010):

- Low: Surface organic layers are not completely consumed and are still recognizable. Soil structure and roots are unchanged, and vegetation will appear green.
- Moderate: Up to 80% of the pre-fire ground cover may be consumed. Fine roots may be scorched but not consumed. Soil structure is not changed and there is usually potential for some immediate cover recruitment.
- High: All or nearly all of the prefire cover and organic matter has been consumed, and soil structure may be completely obliterated or strongly impaired. Fine surface roots have been consumed and coarse roots extending from stump holes may be consumed. There is little to no chance for short-term cover recruitment; cover will not return until vegetation regeneration occurs and snags begin to fall.

Major impacts to soil productivity have occurred in areas with moderate to high SBS. Negative impacts include destruction of the protective vegetation canopy and forest floor, a significant loss of soil carbon and nitrogen, and reduced infiltration capacity, which can lead to landslides, dry ravel (downslope movement of loose, dry particles), and erosion by wind and water causing increased runoff and sediment input into streams (Erickson, 2008).

Wildfire can impact soil in the top 2 to 6 inches (Young, 2010) and given the large nutrient stores in these upper soil layers, it is possible the fire will have caused major losses of nutrient capital in the forest. Soil chemical properties commonly affected by fire include organic matter; nutrient elements such as nitrogen, sulfur, and phosphorus; cations such as calcium, potassium, and magnesium; pH (soil acidity); and buffering capacity. Many of these components interact to influence nutrient availability, which is critical because nutrients often play a key role in

vegetation composition and productivity after fire. The plant nutrient most affected by fire is nitrogen and under severe burns, nitrogen losses in the top few inches soil can range from 72 to 99 percent (Poff, 1996) yet, soil nitrogen at deeper depths is unaffected and overall soil nitrogen loses average approximately 3 percent post fire (Wan, 2001). Ammonium (NH_4^+) and nitrate (NO_3^-) are the main sources of nitrogen for plants and fire is known to increase these. NH_4^+ is released from organic matter with heating, and nitrification, which converts NH_4^+ to NO_3^-, is often stimulated and could remain elevated for approximately 3 years (Wan, 2001).

Displacement is the removal of surface layers of the mineral soil generally by mechanical means. Displacement results in the removal of nutrient surface horizons, exposing the subsurface. This subsurface is deficient in soil nutrients, reduces infiltration, and has higher natural soil strength impeding root penetration.

Surface Organic Matter

All of the project area is meeting the desired condition for surface organic matter. Although many areas of the project have less than 200 cubic feet per acre of large woody debris, there is a high volume of standing dead trees, greater than 12 inch diameter. These would contribute organic material to the soil surface within the next several years and would eventually be cycled into the soil to provide for plant growth.

Post-fire woody debris constitutes a valuable natural element as a potential source of nutrients. Charred wood represents a considerable pool of nutrients including Nitrogen and micronutrients Sodium, Manganese, Iron, Zinc, and Copper (Maranon-Jimenez, 2013). Down woody material greater than 12 inch diameter was surveyed on 11 units within the project area. The average log surveyed had a 15 inch diameter and down woody material greater than 12 inch diameter averages 125 cubic feet per acre. To maintain soil productivity the upper limit of the range of 5 to 10 tons per acre is recommended (Brown, 2003), which equates to approximately 500 cubic feet per acre.

Soil Structure

Within the Westside Recovery project area, soil textures of sandy loam and loam produce moderate compaction ratings (table 3).

Severe soil compaction was measured on approximately 2 percent of the soil plots monitored and approximately 1,500 acres have been impacted by harvest equipment during the last 30 years. Therefore, it’s estimated approximately less than 20 acres of the project area are not meeting desired conditions for soil structure.

Environmental Consequences

Alternative 1

Direct Effects and Indirect Effects

Soil Stability

The soil stability indicator is considered not met when soil cover is less than 30 percent or when EHRs are high. Immediately following the fire, EHRs were high on approximately 57 percent of the project area. Within one year following the fire, soil cover would increase on areas with low to moderate soil burn severities. Soil cover is less likely to increase on areas with high SBS

because tree canopy has been consumed. Therefore, areas with high EHRs would decrease to moderate, except where there is high SBS on approximately 490 acres. These areas would not meet the desired condition for soil stability. Based on field data collected, it is estimated that soil cover is less than 30 percent on this same area.

Under alternative 1, soil cover for erosion protection will be limited to natural rates of accumulation. In areas of low and moderate burn severity, needlecast from dead tree canopies will continue to accumulate as ground cover at natural rates. Soil stability will remain reduced and erosion risk will remain elevated in the short term until ground cover and vegetation return.

Areas with high SBS are lacking effective soil cover and will recover more slowly because potential cover is limited to dead tree branches and boles which will slowly fall. Effective soil cover will only be fully reestablished after surface vegetation recovers. This will expose the soil to higher erosion potential over the next 3 to 6 years (Berg and Azuma 2010).

Table 4: Area (acres) meeting desired condition

Indicator	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1. Acres not meeting desired conditions for soil stability	493	4,236	3,965	3,903	2,027
2. Acres not meeting desired conditions for surface matter	0	825	557	436	456
3. Acres not meeting desired conditions for soil organic matter	658	3,968	3,797	3,650	1,759
4. Acres not meeting desired conditions for soil structure	150	2,045	1,874	1,772	579

Surface Organic Matter

The no action alterative would result in high levels of surface organic matter. Existing large wood in contact with the soil is low, yet snags would fall and accumulate. The average log surveyed had a 15 inch diameter and down woody material greater than 12 inch diameter averages 125 cubic feet per acre. The Fuels Report describes that smaller diameter class snags will fall within the fire perimeter at the highest rate in the first ten years. Larger snags will persist for relatively longer time periods, but most snags will be expected to fall within 20 years post-fire (Hood, Chuck and Smith 2007). Therefore, under the no action alternative large surface organic matter could reach sufficient levels within approximately 5 years and contribute to the recovery of soil productivity. Large woody material decomposes slowly and provides structural habitat for organisms that fix Nitrogen. In addition, it acts as refugia for many organisms, particularly the mycorrhizal fungi which are critical to the health of forest species (Poff, 1996).

It is possible that the surface organic matter indicator would not be met if material greater than 12 inch exceeds 800 cubic feet per acre. If a wildfire occurs during the next 10 to 15 years, soils would burn with a high soil burn severity directly beneath coarse woody debris. High surface temperatures, especially from burning downed logs, raise soil temperatures, resulting in increased volatilization of soil organic matter and long term impacts to soil productivity. Prolonged heating under burning logs will lead to lethal temperatures of greater than 122 degrees Fahrenheit for fungi and 212 degrees Fahrenheit (Debano, 1990) for nitrifying bacteria at greater soil depths. The loss of SOM is probably the most serious concern in terms of long-term soil

effects. Surface organic matter dynamics and nutrient cycling will continue to recover naturally, once vegetation becomes re-established.

Fuels specialist measured 1,000 hour fuel loading on 15 plots, and estimate that one third of these plots could exceed 35 tons per acre of 1,000 hour fuels, which equates to approximately 800 cubic feet per acre of large wood, between year 10 and 15 and cause severe soil heating in a fire (Brown et al. 2003). This plot data has not been extrapolated to the entire project area, yet indicates there could be a potential for severe soil heating on approximately one third of the project area under the no action alternative.

Soil Organic Matter

Under the no action alternative, soil erosion would continue and soil organic matter could be lost, especially on areas with moderate to high EHRs. Soil organic matter would be expected to gradually improve as soils stabilize with decreasing rates of erosion over the next 3 to 6 years. In areas with lower EHRs, organic matter would develop faster, closer to natural rates.

Soil Structure

Soil structure desired conditions are not met when major portions of the area have reduced infiltration and permeability capacity indicated by soil structure and macro-porosity changes. It's estimated approximately less than 20 acres of the project area are not meeting desired conditions for soil structure based on field surveys and past forest management activities.

Under the no action alternative, existing levels of compaction will not be improved or changed. Existing compaction on abandoned roads and skid trails will remain until natural processes restore soil porosity over the long term.

Cumulative Effects

Grazing is the only reasonably foreseeable future action that would occur within the same activity area as this project. Although minimal amounts of grazing activities are ongoing within allotments found within the project area, most of the project activities are proposed on steeper slopes which cattle rarely, if ever, use, or are largely transitory in nature. Further, Annual Operating Instructions, provided to permittees, will limit permitted grazing activities as needed to minimize impacts to not only rangeland health but also soil conditions (see range analysis). For these reasons, no measurable cumulative impacts to soil indicators are anticipated as a result of ongoing grazing activities when added to the activities proposed with this project.

The effects from the 2014 wildfires overwhelm effects from past management practices. The cumulative effects for Alternative 2 would be a continued increase in soil stability due to falling needles, branches, and eventually tree boles. This would result in decreased EHRs and a gradual increase in soil organic matter as material decomposes. These processes would encourage the return of vegetation which would further increase soil cover and eventually soil organic matter. Soil organic matter would reach desired conditions more slowly in areas with high SBS, and recovery could take several decades to a century. Surface organic matter would be expected to reach desired conditions within approximately 10 years. Damage to soil structure would continue to ameliorate, yet this process occurs slowly. The most compacted areas could take approximately 30 years to reach desired condition.

If a wildfire occurs during the next 10 to 15 years and sufficient large woody material is greater than approximately 800 cubic feet per acre, severe soil heating could occur directly beneath large woody material. These areas would not meet desired conditions for soil organic matter due to high soil burn severity.

Alternative 2

Direct and Indirect Effects

Soil Stability

The proposed action is likely to result in less than 30 percent cover and the soil stability indicator would not be met on approximately 30 percent of proposed ground based units, 10 percent of proposed skyline units, and less than 1 percent of helicopter units.

Soil stability would vary due to factors including slope, soil burn severity, soil texture, and soil cover. Proposed actions would impact soil cover and soil burn severity. First, soil cover would be removed due to the construction or reconstruction of approximately 22.5 miles of temporary roads. Then, soil cover would increase as a result of felling trees or mastication. Mechanical disturbance from yarding trees, machine piling of fuels, and pile burning would remove varying amounts of soil cover. Post treatment soil cover would also vary depending on vegetation recovery and tree canopy retained.

Construction of new temporary roads, associated with ground based harvest, would have the highest impact to soil stability and sedimentation (Rice et al. 1972). Skyline units propose approximately twice the length of temporary roads compared to helicopter and ground based units. Impacts to soil stability would depend on the depth of soil excavated during construction, and existing soil stability. If soil cover is sufficient to limit accelerated erosion on existing temporary roads proposed for reconstruction, or on decommissioned roadbeds proposed for use, then, its removal during construction would result in impacts to soil stability. On other sections of existing or decommissioned road, soil may be detrimentally compacted, or severely eroded. Then, reconstruction and project design features to decommission the temporary road post-harvest, could improve soil stability over the long term.

Soil erosion associated with forest roads is particularly severe during the first year or two after construction, before cut banks and fill slopes have revegetated and stabilized (Peterson, 2009). Forest roads are the largest source of erosion and this is exacerbated in a burned environment because the capacity of the landscape to moderate flow and trap sediment is greatly reduced (Peterson, 2009). PDFs would require subsoiling 60 percent of new temporary roads and landings, and would require maintaining at least 50 percent effective soil cover. This would promote the recovery of soil stability yet soil stability would remain impacted over the long term on existing or previously decommissioned temporary roads, and existing landings. In addition, the Timber Sale Contract clause, B6.63 Temporary Roads, requires the purchaser to employ such measures as outsloping, drainage dips, and water-spreading ditches to limit accelerated erosion.

Construction of 46 new ground based landings would also result in impacts to soil stability and would vary depending on the amount of soil excavated. Approximately 53 existing landings are proposed for use which may require expansion and some impacts to soil stability.

Ground based and skyline harvest would be expected to fell the most trees per acre resulting in the highest addition of soil cover, approximately 10 to 20 percent. When ground based, skyline,

or helicopter treatments overlap with roadside hazard units, the number of trees felled would increase by following the Regional Hazard Tree Guidelines for Forest Service Facilities and Roads in the Pacific Southwest Region (Angwin et al. 2012)

Ground based harvest would result in the highest percent of ground disturbance (Beschta, 2004). Overall, ground based harvest would be expected to disturb soil on approximately 30 percent, and up to 40 percent where roadside hazard, machine piling and pile burning treatments also occur. Mechanical disturbance or pile burning would remove soil cover and impact new vegetation growth. Post salvage monitoring of the Panther Fire Salvage (KNF) and American Fire Salvage (Tahoe National Forest) indicate that approximately 30 percent of the unit areas were impacted by ground based equipment. Chou et al. (1994) measured an average of 35 percent, and Chase (2006) measured 22 percent soil disturbed on ground based salvage units. Monitoring of previous ground based salvage units on the KNF has found an increased amount of disturbance on secondary skid trails compared to green timber sales due to a lack of a protective duff mat on the soil surface (USDA, 2012b).

After road construction or reconstruction, proposed skyline harvest is expected to impact soil cover, mostly during the construction of approximately 51 new landings. The dragging of logs through cable corridors is expected to remove soil cover on less than approximately 10 percent.

Helicopter logging is expected to remove soil cover on the construction of 55 new landings. Approximately 34 existing landings are proposed for use which may require expansion and some impacts to soil stability. Impacts to soil stability during helicopter harvest would be isolated to landings which would cover approximately less than 1 percent.

Post fire accelerated erosion due to ground based salvage logging could result in a 6 to 1,000 fold increase in sediment production (Wagenbrenner, 2015). This would mainly occur due to reduced infiltration on skid trails and disturbed areas, which would concentrate runoff as rill erosion. Where skidding occurs through areas with less than 50 percent soil cover, the PDF would require applying at least 50 percent soil cover on skid trails greater than 15 percent slope. Based on monitoring from the American Fire Salvage, this PDF is difficult to implement unless a watershed specialist identifies skid trails needing treatment. Soil cover is so variable within units following harvest it can be difficult to predict which skid trails are at highest risk for accelerated erosion. Yet, when applied, especially at rates of 50 to 100 percent, mulch can be very effective to improve soil stability and mulch would be expected to reduce sediment delivery by 5 to 50 times (Wagenbrenner, 2015). Adding slash to skid trails would also improve soil stability by increasing the effectiveness of water bars (Robichaud, 2011).

Vegetation recovery and subsequent ground cover could lag behind undisturbed areas by three years or more (Robichaud, 2011). Seedlings that germinate following a wildfire may be damaged or killed by mechanical disturbance associate with subsequent salvage logging (Van Nieuwstadt, 2001). Areas most heavily impacted such as landings and main skid trails would be the slowest to recover. Ground based harvest would be expected to delay vegetation recovery on up to 30 percent of a units area, and ground based harvest of roadside hazard could impact 30 to 60 percent. Vegetation began to recover almost immediately following the fires and will continue to add soil cover and increase soil stability where undisturbed.

Mechanical piling and burning of woody debris during site preparation would impact soil stability if these activities are conducted before at least 50 percent new vegetation returns. One PDF would prevent mechanical site prep from occurring in areas where soil cover is less than 70

percent and would require achieving this amount of cover post-treatment. Another PDF would require low ground pressure ground based equipment to be used during site preparation if a watershed specialist identifies ground based units that are near disturbance thresholds post-harvest. Effective implementation of both these PDFs would limit additional impacts to soil stability from site preparation. Overall, proposed actions of site preparation and planting of conifers may or may not result in a net benefit to soil stability. A net benefit to soil stability could occur where high amounts of brush or lack of seed source would otherwise delay conifer regeneration under the no action alternative, and therefore crown closure and the stabilization of soil productivity (Poff, 1996).

Proposed underburning would have minimal impacts to soil stability. The greatest impacts would occur due to line construction activities where dozers are used to re-scrape control lines to mineral soil. Where control lines are inaccessible for equipment, hand-line construction to mineral soil would occur. The fuels PDF would minimize the construction of control line by requiring use of natural features such as ridgelines, streams and rock outcroppings for control features when prescribed burning.

Proposed fuel management zones would maintain existing control lines by removing all dead vegetation, live understory vegetation, and conifer trees less than 12 inches in diameter at breast height. On approximately 42 acres with high SBS, litter in contact with the soil has been consumed and live and dead vegetation may be the only effective soil cover. On these areas, proposed hand treatments could impact soil stability if plant material is removed rather than scattered. Proposed use of mechanical equipment to remove vegetation could result in additional bare soil. Overall, it’s estimated fuels management zones could not meet desired conditions for soil stability on approximately 10 percent of the area treated.

By design, underburning is typically low severity, and would burn 60 to 80 percent of a unit. In the southern Sierra Nevada, a median of less than 90 percent soil cover remained on 130 plots following prescribed burning treatments (Berg and Azuma, 2010). On approximately 485 acres, underburning is proposed following harvest activities. Fuel loading is expected to be less than 35 tons per acre post- harvest and impacts to soil cover would be small and isolated and therefore unlikely to impact soil stability.

Proposed legacy site treatments would be designed to improve soil stability over the long term. Minor, localized impacts to soil stability could occur due to culvert replacements and road maintenance, yet implementation of best management practices would maintain soil cover on disturbed areas. Road maintenance would have a beneficial impact to soil stability by improving drainage and decreasing the potential for rill and gully erosion. Likewise, culvert upgrades would decrease the diversion potential of drainages and resulting accelerated erosion.

Under alternative 2, it’s estimated approximately 4,236 acres of the project area would not meet desired conditions for soil stability (see table 6) because soil cover would be less than 30 percent. EHRs consider additional factors that impact soil stability such as slope, soil texture, and the potential for soil runoff based on soil depth and infiltration. Mechanical disturbance as described above, would result in high EHRs on slopes greater than 15 percent. Therefore, EHRs would be high or very high on most of the 2,800 acres with bare soil.

Surface Organic Matter

Approximately 900 acres may not meet the desired condition for surface organic matter due to insufficient retention of large woody material. However, a scarcity of large wood may not necessarily translate to reduced soil productivity, for a couple of reasons. First, heavily charred wood decays much more slowly; lots of smaller diameter material would be expected to remain longer. Second, coarse wood doesn't contribute that much to soil fertility – it's carbon rich and nutrient poor, so it contributes some carbon for SOM, but most of the carbon goes off as carbon dioxide from microbial respiration as it decays (Spears, 2003). Also, formation of SOM is a much longer term process than the period of wood scarcity, and soil carbon has a huge buffering capacity because it is such a large source of carbon.

The proposed action would result in removal of large standing surface organic matter, which may not meet the surface organic matter indicator following proposed ground based and skyline harvest. , and would meet the desired condition of at least 500 cubic feet per acre.

Impacts to surface organic matter would vary based on the amount and diameter of material removed. This would mainly occur on proposed ground based and skyline units and could vary greatly depending on size and merchantability of timber. For example, if there is a high amount of non-merchantable, large diameter material, this material would remain on site and the surface organic matter indicator would be more likely to be met.

Proposed treatments would increase surface organic matter over the short term, and decrease the potential for surface organic matter over the long term. When a tree is killed, dead needles not consumed by fire fall to the forest floor within one to two years, followed by branches, and eventually boles. Cutting of trees during proposed harvest, site prep, and fuels reduction treatments would accelerate this process. Harvest activities would remove some trees that had a 30 percent chance of survival, (40 percent for hazard tree). Therefore, some trees would be removed which would otherwise survive and continue to drop fine surface organic matter over the long term. Proposed pile burning activities would remove finer surface organic matter of less than approximately 6 inch diameter. Yarding merchantable material off site would lower the density and average size of remaining dead trees (Peterson, 2009) and decrease the potential for surface organic matter over the long term.

Ground based and skyline harvest could result in less than 200 cubic feet of large wood per acre, resulting in minor impacts to soil productivity, mostly in the top 4 inches soil (Maranon-Jimenez, 2013). On proposed harvest units, snags would be retained within riparian reserves and a wildlife PDF would require leaving larger snags within Northern Spotted Owl critical habitat. Effective implementation of these PDFs would slowly add 200 to 800 cubic feet of large woody debris as these trees eventually fall. However, these PDFs would not apply to approximately 1,200 acres where ground based and skyline harvest is proposed. Another wildlife PDF would require retention of preexisting snags, and in addition to this, larger non-merchantable material may be sufficient to meet the desired condition. Overall, approximately 900 acres may not meet the desired condition for surface organic matter due to insufficient retention of large woody material.

Piling and burning of large woody debris associated with proposed site preparation and fuels treatments would also reduce large wood. The PDF would prevent site preparation from decreasing large woody debris, greater than 8 inch diameter, below 7 tons per acre which equates to approximately 500 cubic feet per acre. Effective implementation of this PDF would limit detrimental impacts to surface organic matter.

Underburning is mostly proposed on areas where there is a high potential for surface organic matter to be added from standing dead trees. Underburning could consume some surface organic matter, yet it could result in some tree mortality which would increase surface organic matter. Stephens and Moghaddas (2005) found that use of prescribed fire did not significantly change the volume of down woody material compared to no treatment. Underburning is proposed on approximately 485 acres following ground based harvest and there is a slight potential it could further reduce surface organic matter. Yet, where surface organic matter is low, underburning would be less likely to carry through the unit, and surface organic matter would be less impacted.

Soil Organic Matter

It is anticipated that SOM would not meet desired conditions on approximately 20 percent of units proposed for both ground based harvest and mechanical fuel reduction or site preparation, 15 percent of ground based harvest units, 10 percent of skyline units, and less than 1 percent of proposed helicopter units. Less soil organic matter would decrease soils ability to hold moisture, with implications for soil biota, and plant growth (Brown, 2003).

The most severe displacement of SOM is expected to occur during temporary road construction and on landings and main skid trails. Temporary road construction would result in the highest impacts to SOM, especially on steeper side slopes which would require excavation of a cut slope. Ground based skid trails would result in displacement of SOM on skidder tracks, and where yarded trees dig into the mineral soil surface and wedge the surface to the side. This creates berms and piles along the edges of skid trails. Soil disturbance is greater on steeper slopes, and a PDF would limit ground based skidding to slopes less than 35 percent or short pitches of 100 feet on slopes less than 45 percent. Displacement caused by new skid trails and temporary road construction will be considered a long-term disturbance as no mitigations to replace displaced SOM are planned. On proposed harvest units, jackpot pile burning would be expected to produce enough heat to consume SOM within the footprint of the piles.

On ground based units, mechanical disturbance off of main skid trails could result in major impacts to SOM if the existing SOM is low, or if long term accelerated erosion occurs due to insufficient soil cover. Approximately 20 percent of the proposed ground based units have forest survey site class ratings of 4 and 5, which are lower productivity on a scale of 1 to 7. On these soils, fewer passes of mechanical equipment could result in detrimental impacts to soil organic matter and soil productivity.

A Non-Native Invasive Plant PDF would require removal of the top few inches soil on approximately 24 landings. This would result in major decreases to SOM soil on landings, yet could benefit soil productivity off of landings, if it results in fewer NNIPs within units.

In addition to ground based harvest, machine piling is proposed on slopes less than 35 percent for site preparation treatments. Machine piling is also proposed on approximately 100 acres of fuel management zones. Fox et al. (1989) found displacement caused by mechanical windrowing decreased forest productivity dramatically. Where mechanical piling also occurs, an additional 5 percent (approximately) of ground based units would not meet soil organic matter due to displacement of the soil and burning of larger piles. A PDF would require site preparation treatments to be designed to meet the KNF Forest Plan soil management direction. Pile burning typically occurs in the wetter months when soils are slightly moist or wetter and a PDF would also limit pile size. Burning smaller piles on wetter soils are unlikely to result in major impacts to SOM. The extent and burn severity is unknown and is dependent on the size of the piles and

distribution of fuels. The impact will be limited to the pile locations and small areas of high concentrations and therefore is not expected to be significant.

Manual release treatments are proposed following planting or natural regeneration and include manually removing all vegetation within a minimum 5 foot radius circle from a seedling. This is only likely to impact soil organic matter if insufficient soil cover remains and accelerated erosion removes SOM off site.

On both skyline and helicopter units, the greatest impact to SOM would occur during new construction of landings. Jackpot burning would also occur on landings and would produce enough heat to consume SOM within the footprint of the piles. Skyline units are expected to have displacement along portions of the corridors, with higher displacement levels occurring closer to the landings. On both skyline and helicopter units, feller-buncher equipment is proposed on slopes 35 to 45 percent. A PDF would restrict their use to slopes less than 35 percent on sensitive soils with Granitic or Schist parent material, and soils where soil cover is very low (less than 30 percent). Displacement from harvesters is generally not considered detrimental because the effects are localized.

By design, proposed underburning would result in low soil burn severity and therefore would have minimal impacts to soil organic matter. Low severity underburning could have beneficial impacts to soil organic matter (Haase and Sackett 1998).

Soil Structure

It is expected soil structure would not meet desired conditions on approximately 20 percent of ground based harvest units with additional mechanical site preparation or fuel reduction, 15 percent of ground based harvest units, and less than 1 percent of skyline and helicopter units. Reduced infiltration and permeability capacity is expected due to the use of mechanical equipment on landings, skid trails, and new temporary roads. Construction of new landings, and temporary roads would reduce infiltration to near zero.

Where treatments are proposed with mechanical equipment, soil types are rated with moderate compaction ratings. Changes in porosity occur both by the reduction of soil pore space by force applied to the soil surface (compaction) and the filling of pores by soil and ash material (soil sealing).

Within tractor units, detrimental compaction is expected on skid trails, landings and temporary roads. Williamson and Neilson (2000) found that maximum compaction occurs after 3 passes of log-laden equipment. Landings are areas of high compaction because they support skidding equipment, processors, and log trucks. The PDF to space skid trails at least 75 feet would confine the extent of detrimental disturbance from skid trail patterns to less than 15 percent of a unit. The PDF to subsoil temporary roads, select skid trails and landings would substantially decrease the negative effects of compaction. Approximately 60 percent of ground based landings and temporary roads would be subsoiled. Powers (2002) observed that subsoiling significantly improved the porosity of soils.

On proposed skyline units, no skid trails will be used. Except for landings, and new temporary roads, detrimental compaction is not expected outside cable corridors.

Detrimental disturbance is expected to be minimal in helicopter units and would occur on landings or where feller-buncher type harvesters assist handfallers in removing trees. Feller-buncher harvesting equipment is considered low ground-pressure equipment and typically does

not travel the same location more than twice. Compaction is therefore expected to be slight where mechanical harvesting occurs.

Wildfire Following the Proposed Action

If a wildfire re-burns the project activity area following the proposed action, impacts to soil would be spatially localized and would occur beneath large woody material in contact with the soil. High soil burn severity would likely occur beneath large woody material, greater than approximately 6 inches, in contact with the soil. These impacts are only likely to occur if a wildfire burns approximately 10 to 15 years from now. After this time, large woody material would mostly be decomposed and finer fuels would not have accumulated to such a depth as could cause severe soil heating. Before 10 years, a wildfire following the proposed action is unlikely to carry through treated areas because new growth, and therefore finer fuels, would not have accumulated. Compared to the no action alternative, fewer large dead trees would be available to fall thus resulting in fewer acres of high soil burn severity.

Cumulative Effects

Past effects due to forest management and the 2014 fires have been considered and discussed in the direct and indirect effects analysis. In summary, wildfire and forest management have impacted soil stability, surface organic matter, soil organic matter and soil structure. These impacts have been described in the existing condition and analyzed in the effects analysis. The highest cumulative impacts to soil stability and surface organic matter would occur when mechanical equipment is used on soil that burned with a high soil burn severity. Cumulative impacts to soil structure would occur 70 acres proposed for ground based harvest, where harvest has occurred in the past 10 years. There are no reasonably foreseeable future actions that would occur within the same activity area as this project.

Adding the effects of alterative 2 to the effects of past, present, and reasonably foreseeable future actions could have substantial negative effects on soil desired conditions. PDFs have been developed to maintain soil cover and restrict additional use of mechanical equipment when desired conditions are most likely not met.

Alternative 3

Direct and Indirect Effects

Soil Stability

Alternative 3 would propose approximately 670 fewer acres ground based harvest, 460 fewer acres helicopter and 658 fewer acres skyline harvest compared to alternative 2, therefore, fewer acres would be impacted by mechanical equipment.

Alternative 3 proposes 1,215 fewer acres of fuel management zone treatments. This would decrease the area that would not meet desired conditions by approximately 10 acres, where there is high SBS, because less soil cover would be removed due to use of mechanical equipment and removal of vegetation providing soil cover.

Under alternative 3, mechanical equipment would remove soil cover on approximately 940 acres and in addition to 495 acres, which would have high EHRs under the no action alternative, a total

of approximately 1,435 acres of the project area would not meet desired conditions for soil stability (see table 5).

Surface Organic Matter

In addition to harvesting fewer acres, alternative 3 would retain more large trees within ground based harvest units. Retention of 5 to 8 large dead trees per acre would meet the desired condition for surface organic matter.

Soil Organic Matter

Fewer acres proposed for ground based harvest, and fuel management zone treatments would result in less impact to SOM because less area would be impacted by mechanical equipment. It's estimated approximately 1,750 acres would not meet desired conditions for SOM under alternative 3. This is a decrease of 230 acres compared to alternative 2.

Soil Structure

Fewer acres proposed for ground based harvest would result in less compaction. It's estimated alternative 3 would result in approximately 850 acres with reduced infiltration, which is 170 acres less than the proposed action.

Wildfire following the proposed action

If a wildfire re-burns the project activity area following alternative 3, more large dead trees would be available to fall and result in high soil burn severity. This could occur beneath large woody material in contact with the soil if a wildfire burns approximately 10 to 15 years from now. Compared to alternative 2, this could occur on 180 acres more, where harvest would not occur.

Cumulative Effects

The cumulative effects of alternative 3 would be very similar to alternative 2. Adding the effects of alterative 3 to the effects of past, present, and reasonably foreseeable future actions could have substantial negative effects on soil desired conditions. The highest cumulative impacts to soil stability and surface organic matter would occur when mechanical equipment is used on X acres of soil that burned with a high soil burn severity. PDFs have been developed to maintain soil cover and restrict additional use of mechanical equipment when desired conditions are most likely not met.

Alternative 4

Direct and Indirect Effects

Soil Stability

Alternative 4 would propose approximately 102 fewer acres ground based harvest, 1,520 fewer acres skyline and 135 more acres helicopter compared to alternative 2, therefore, fewer acres would be impacted by mechanical equipment. In addition, 2.4 miles less temporary roads would be constructed, 15.8 miles less existing and previously decommissioned roads would be used, 10 fewer existing landings would be used, and 40 fewer new landings would be constructed.

The decreased use of landings would result in the greatest decrease, approximately 50 acres, of area not meeting the soil stability indicator. Less ground based harvest would result in approximately 30 fewer acres where soil stability is not met, and 16 fewer acres because less temporary roads would be used or constructed.

Alternative 4 proposes 1,215 fewer acres of fuel management zone treatments. This would decrease the area that would not meet desired conditions by approximately 10 acres, where there is high SBS, because less soil cover would be removed due to use of mechanical equipment and removal of vegetation providing soil cover.

Under alternative 4, mechanical equipment would remove soil cover on approximately 1,450 acres and in addition to 495 acres, which would have high EHRs under the no action alternative, a total of approximately 1,945 acres of the project area would not meet desired conditions for soil stability (see table 5). This is 360 fewer acres compared to alternative 2.

Surface Organic Matter

Alternative 4 proposes to harvest fewer ground based and skyline units. Therefore, approximately 440 acres would not meet the surface organic matter indicator, which is 390 fewer acres compared to alternative 2.

Soil Organic Matter

Fewer acres proposed for ground based harvest, and fuel management zone treatments would result in less impact to SOM because less area would be impacted by mechanical equipment. It's estimated approximately 1,450 acres would not meet desired conditions for SOM under alternative 3. This is a decrease of 530 acres compared to alternative 2.

Soil Structure

Fewer acres proposed for ground based harvest would result in less compaction. It's estimated alternative 3 would result in approximately 790 acres with reduced infiltration, which is 230 acres less than the proposed action.

Wildfire following the proposed action

If a wildfire re-burns the project activity area following alternative 4, more large dead trees would be available to fall and result in high soil burn severity. This could occur beneath large woody material in contact with the soil if a wildfire burns approximately 10 to 15 years from now. Compared to alternative 2, this could occur on 1,485 acres more, where harvest would not occur.

Cumulative Effects

The cumulative effects of alternative 4 would be very similar to alternative 2. Adding the effects of alterative 4 to the effects of past, present, and reasonably foreseeable future actions could have substantial negative effects on soil desired conditions. The highest cumulative impacts to soil stability and surface organic matter would occur when mechanical equipment is used on X acres of soil that burned with a high soil burn severity. PDFs have been developed to maintain soil cover and restrict additional use of mechanical equipment when desired conditions are most likely not met.

Alternative 5

Direct and Indirect Effects

Soil Stability

Alternative 5 would propose approximately 415 fewer acres ground based harvest, 4,525 fewer acres skyline and 3,675 fewer acres helicopter compared to alternative 2, therefore, fewer acres would be impacted by mechanical equipment. In addition, 29 fewer existing landings would be used, and 18 fewer new landings would be constructed.

Less ground based harvest would result in the greatest decrease, approximately 125 acres, of area not meeting the soil stability indicator. Fewer landings used would result in approximately 115 fewer acres where soil stability is not met.

Under alternative 5, mechanical equipment would remove soil cover on approximately 1,100 acres. In addition to 495 acres, which would have high EHRs under the no action alternative, a total of approximately 1,600 acres of the project area would not meet desired conditions for soil stability (see table 5). This is 715 fewer acres compared to alternative 2.

Surface Organic Matter

Alternative 5 proposes to harvest fewer ground based and skyline units. Therefore, approximately 460 acres would not meet the surface organic matter indicator, which is 370 fewer acres compared to alternative 2.

Soil Organic Matter

Fewer acres proposed for ground based harvest, and fuel management zone treatments would result in less impact to SOM because less area would be impacted by mechanical equipment. It's estimated approximately 1,030 acres would not meet desired conditions for SOM under alternative 5. This is a decrease of 960 acres compared to alternative 2.

Soil Structure

Fewer acres proposed for ground based harvest would result in less compaction. It's estimated alternative 5 would result in approximately 370 acres with reduced infiltration, which is 650 acres less than the proposed action.

Wildfire following the proposed action

If a wildfire re-burns the project activity area following alternative 5, more large dead trees would be available to fall and result in high soil burn severity. This could occur beneath large woody material in contact with the soil if a wildfire burns approximately 10 to 15 years from now. Compared to alternative 2, this could occur on 8,61 acres more, where harvest would not occur.

Cumulative Effects

The cumulative effects of alternative 5 would be very similar to alternative 2. Adding the effects of alterative 5 to the effects of past, present, and reasonably foreseeable future actions could have negative effects on soil desired conditions. The highest cumulative impacts to soil stability and surface organic matter would occur when mechanical equipment is used on soil that burned with

a high soil burn severity. PDFs have been developed to maintain soil cover and restrict additional use of mechanical equipment when desired conditions are most likely not met.

Summary of Effects

As shown in Table 6, alternative 1 would result in the recovery of soil stability and SOM except for on approximately 660 acres with high SBS. SOM would slowly recover as soil stability increases.

On approximately 4,240 acres, soil stability and SOM would be impacted with most disturbance on temporary roads and landings. This is less than 10 percent of the total project area that would not meet desired conditions. For alternatives 3 and 4, approximately 5 percent more area would meet desired conditions compared to alternative 2 because these alternatives propose fewer acres of ground based harvest and fuel management zone treatment. Alternative 5 proposes fewer acres of ground based harvest and fuel management zone treatment compared to alternatives 3 and 4. Furthermore, fewer temporary roads and landings would reduce impacts to soil stability, SOM, and soil structure. Therefore, under alternative 5, approximately 57 percent more area would meet desired conditions compared to alternative 2.

Compliance with law, regulation, policy, and the Forest Plan

Although soil indicators would not be met on about 4,000 acres, this is less than 10 percent of the project area. Therefore, Standard and Guidelines 3-1, and 3-2 would be met at the project scale. A forest consistency checklist has been completed that reviews the soil standards and guidelines. Standard and Guidelines 3-3 through 3-6 would be met because project activities are not expected to result in major decreases to surface organic matter and soil organic matter. Standard and Guideline 3-7 has been met by the selection of soil plots where soils were field verified. The greatest impacts to soil productivity would occur due to impacts to soil stability and SOM on approximately 30 percent of ground based harvest units and on new temporary roads and new landings associated with proposed ground based, skyline, and helicopter harvest units. Overall, this area is less than 10 percent of the entire project area.

Table 5: Compliance with Forest-wide Standards and Guidelines for Soil

S&G No.	LRMP Direction	Project Conformance to S&G
Soils		
3-1	Plan and implement land management activities to maintain or enhance soil productivity and stability.	Not met on approximately 2,000 acres for Alternative 2, and 1,500 acres for alternative 3 through 5.
3-2	Maintain soil cover of 70% or 80% (depending upon slope and soil type) on tractor units; maintain soil cover of 50% to 80% on prescribed burn units, depending upon slope and soil type (see LRMP, pg. 4-20). With the exception of roads, permanent facilities or other projects that will permanently occupy a site, the following levels of total soil cover should be maintained at the stand level to reduce the potential of soil erosion (see LRMP for the levels of total soils cover table):	Not met on approximately 2,000 acres for Alternative 2, and 1,500 acres for alternative 3 through 5..
3-3	Maintain soil productivity by retaining organic material on the soil surface and by retaining organic material in the soil profile.	Not met on approximately 2,000 acres for Alternative 2, and 1,500 acres for alternative 3 through 5.

3-4	A minimum of 50% of the soil surface should be covered by fine organic matter following project implementation, if it is available on site.	Complies.
3-5	Maintain a minimum of 85% of the existing soil organic matter in the top 12 inches of the soil profile to allow for nutrient cycling and maintain soil productivity.	Not met on approximately 2,000 acres for Alternative 2, and 1,500 acres for alternative 3 through 5.
3-6	Refer to the Coarse Woody Debris (CWD) section of Biological Diversity under Biological Environment for coarse woody debris standards and guidelines designed to maintain soil fertility and provide for species needs.	Complies.
3-7	Complete a Soils Resource Inventory Order 2 inventory when necessary, or field verify the Soils Resource Inventory Order 3 survey, during the planning and implementation phase of each site-disturbing or vegetative manipulation project. Develop soil conservation management practices for each project as needed.	Complies. The Order 3 soil survey was field verified during the planning of this project

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Appendix A

Table A- 1: Soil Map Units within the Westside Fire Recovery

Soil Map Unit	Map Unit Name	Acres
101	Aiken family, 15 to 50 % slopes	3
102	Aiken family-Dumps, mine tailings assn., 2 to 30 % slopes	44
106	Bluesprin family-Lithic Mollic Haploxeralfs assn., 30 to 70 % slopes	183
107	Buell family, 2 to 30 % slopes	9
109	Clallam family, deep, 15 to 70 % slopes	622
110	Clallam family, very deep, 9 to 70 % slopes	98
112	Clallam, deep-Deadwood families assn., 50 to 90 % slopes	9181
113	Clallam, deep-Holland families assn., 30 to 70 % slopes	1561
114	Clallam, deep-Goldridge, gravelly families assn., 30 to 90 % slopes	984
115	Clallam family, very deep-Riverwash assn., 0 to 15 % slopes	802
116	Coboc-Holland families assn., 2 to 15 % slopes	133
118	Deadwood-Clallam, deep families assn., 50 to 90 % slopes	4356
119	Deadwood family-Rock outcrop assn., 50 to 90 % slopes	446
122	Dubakella family, 30 to 70 % slopes	420
123	Endlich-Buell families assn., 15 to 70 % slopes	54
124	Entic Xerumbrepts-Gerle family assn., 30 to 90 % slopes	56
127	Gerle family-Entic Xerumbrepts assn., 50 to 90 % slopes	722
128	Gilligan-Chawanakee families assn., 30 to 90 % slopes	3129
129	Gilligan-Goldridge families assn., 30 to 90 % slopes	3049
130	Gilligan-Holland families assn., 15 to 70 % slopes	368
131	Goldridge family, gravelly, 15 to 50 % slopes	850
132	Goldridge, gravelly-Clallam, deep-Prather families assn., 30 to 90 % slopes	309
133	Goldridge-Gilligan families assn., 15 to 90 % slopes	6
134	Guemes family, 30 to 90 % slopes	203
138	Holland family, 15 to 50 % slopes	127
139	Holland-Aiken families assn., 2 to 15 % slopes	111
141	Holland-Clallam, deep-Coboc families assn.s, 15 to 70 % slopes	5429
142	Holland-Gilligan families assn., 30 to 90 % slopes	176
143	Holland-Skalan families assn., 15 to 30 % slopes	1421
144	Holland-Skalan families assn., 30 to 70 % slopes	1929
147	Inville-Wintoner families assn., 30 to 50 % slopes	762
150	Jayar-Woodseye families assn., 30 to 70 % slopes	5198
151	Kang-Beaughton families assn., 9 to 90 % slopes	543

Soil Map Unit	Map Unit Name	Acres
153	Lithic Haploxeralfs-Holland family assn., 30 to 70 % slopes	41
155	Lithic Mollic Haploxeralfs-Dubakella family assn., 15 to 70 % slopes	250
157	Lithic ruptic-Xerochreptic haploxeralfs-Olete family assn., 30 to 90 % slopes	404
158	Lithic ruptic-Xerochreptic haploxeralfs-Parks family assn., 30 to 90 % slopes	143
160	Lithic Xerorthents, granitic-Rock outcrop assn., 50 to 90 % slopes	179
161	Lithic Xerorthents, ultramafic, 30 to 70 % slopes	20
162	Lithic Xerumbrepts-Rock outcrop assn., 15 to 90 % slopes	53
165	Nanny family, 2 to 30 % slopes	58
166	Nanny family, 30 to 50 % slopes	134
168	Olete family-Lithic ruptic-Xerochreptic haploxeralfs assn., 30 to 90 % slopes	788
171	Parks family-Lithic ruptic-Xerochreptic haploxeralfs assn., 30 to 90 % slopes	504
174	Riverwash	345
176	Rogue-Jayar families assn., 30 to 50 % slopes	452
182	Skalan-Clallam,deep families assn., 30 to 70 % slopes	156
183	Skalan-Clallam,deep-Decry families assn., 15 to 70 % slopes	1062
184	Skalan family-Lithic Haploxeralfs assn., 30 to 90 % slopes	367
185	Skalan family-Lithic Mollic Haploxeralfs associatiion, 30 to 70 % slopes	887
186	Tallac-Nanny families assn., 9 to 30 % slopes	1
187	Tallac family-Ultic Haploxeralfs assn., 15 to 50 % slopes	383
188	Tangle family, 15 to 50 % slopes	46
193	Typic Haploxerolls-Lithic Haploxerolls-Rpck outcrop complex, 30 to 90 % slopes	86
196	Weitchpec family-Lithic Haploxeralfs assn., 30 to 90 % slopes	316
197	Woodseye family-Rock outcrop assn., 50 to 90 % slopes	591
198	Woodseye-Jayar families assn., 30 to 70 % slopes	1262

Figure A- 1: Map of soil units within the beaver fire area

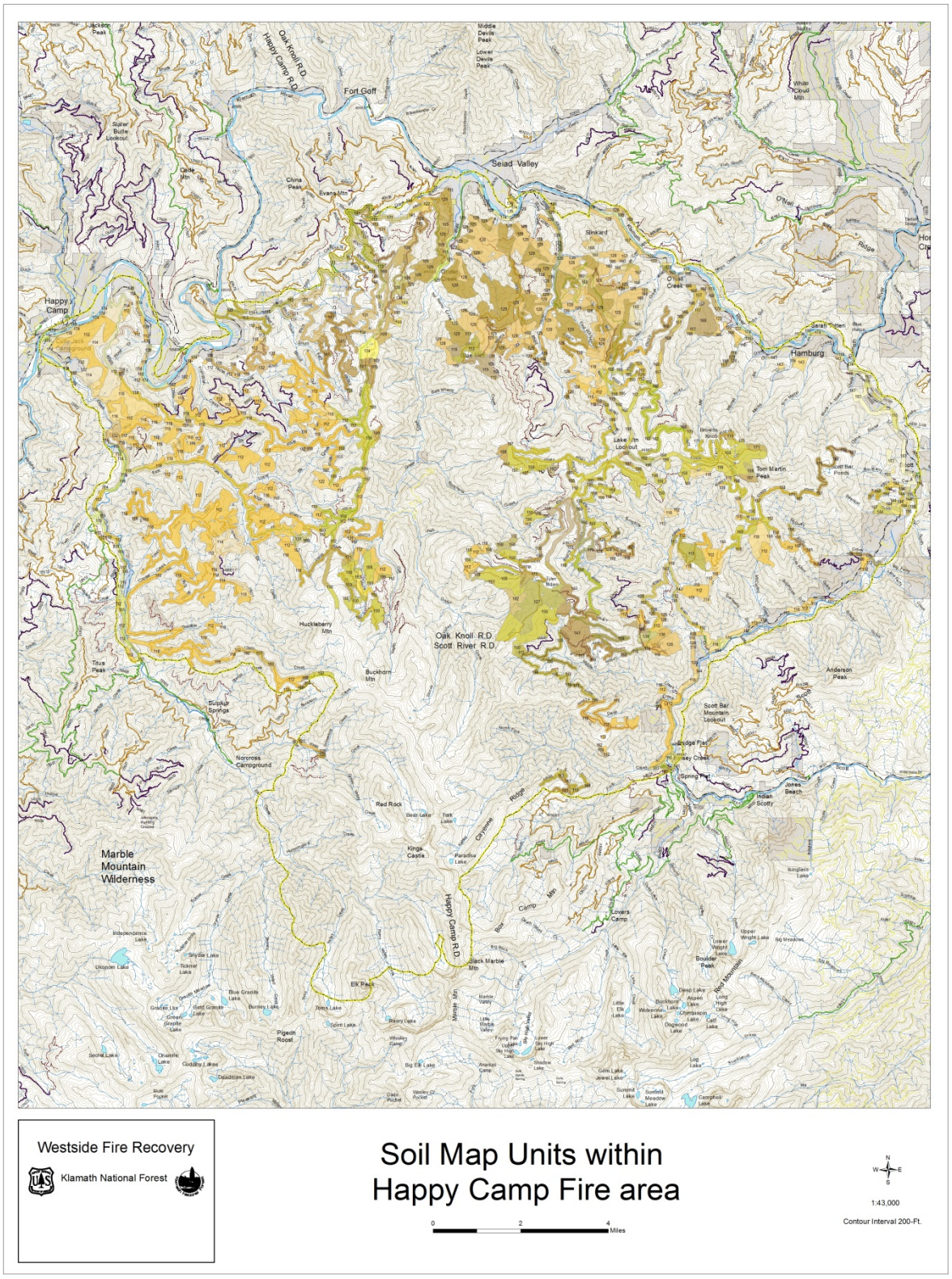

Figure A- 2: Map of soil units within the happy camp fire area

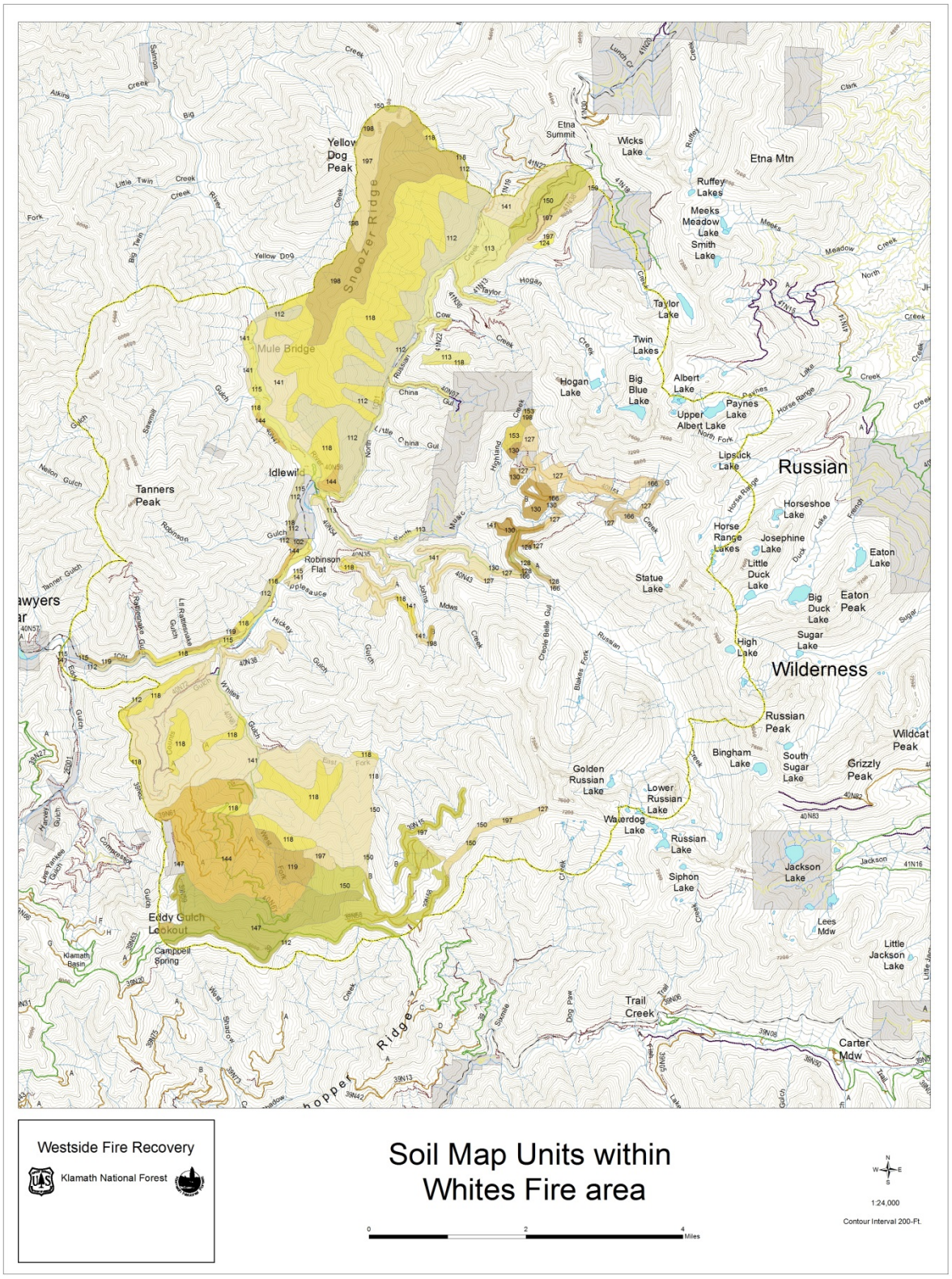

Figure A- 3: Map of soil units within the whites fire area