French Fire Recovery and Reforestation Project
Soil Specialist Report
Bass Lake Ranger District

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Introduction

Overview of Issues Addressed

Support for Plant Growth Function
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.

The natural physical structure of the soil provides a favorable environment for root growth. The organic matter on the soil surface and within the mineral soil is a major source of ecosystem nutrients such as nitrogen, essential for plant growth. It is important to realize that surface organic matter levels fluctuate naturally over time. The amount of organic matter is a balance of inputs from vegetation and decomposition rates dependent upon the local climate. Fire and management can decrease surface organic matter temporarily but accumulation resumes with natural vegetative growth within a relatively short time frame (years to decades). Very fine, amorphous organic matter in the mineral soil, referred to as soil organic matter (SOM), has accumulated over long time periods (decades to centuries) from root turnover and the biomass of soil organisms. And because it is not readily subject to burning per season, the organic matter level in the mineral soil is more stable than that on the surface. SOM is a very valuable source of nutrients, increases the available water-holding capacity and contributes to the formation and stability of soil structure. The conservation of organic matter in the mineral soil and on top of the soil is fundamental to maintaining the Support for Plant Growth function.

Soil Hydrologic Function
The soil hydrologic function is the inherent capability of the soil to absorb, store and transmit water within the soil profile. The capability is dependent upon an adequate level of cover to reduce rainfall impact and runoff energy, stable soil structure, and sufficient macro-porosity to permit water infiltration and movement through the soil.

Filtering-Buffering Function
The soil acts as a filter and buffer to protect the quality of water, air, and other resources by immobilizing, degrading or detoxifying chemical compounds or excess nutrients. The actual effectiveness of the soil filtering and buffering function is dependent upon the particular physical, chemical, and biological properties of the soil types involved, properties of the chemical(s), and the climate or leaching environment.

Issue Indicators
1) Support for Plant Growth Function
   a. Soil Stability
   b. Surface Organic Matter
   c. Soil Organic Matter (SOM)
   d. Soil Strength
2) Soil Hydrologic Function
   a. Soil Stability
b. Soil Structure & Macro-porosity

3) Filtering - Buffering Function

a. No indicators are provided; describe any recommendations to prevent undesirable effects to soil micro-organisms, post-project erosion risk, leaching potential and risk of off-site movement of the chemicals.

Affected Environment

Existing Condition
Soils in the proposed project area vary in their sensitivity to management from soil map unit to soil map unit. Soil disturbance is considered as any activity that results in the loss of soil stability, decreased amounts of either or both surface organic matter or soil organic matter, increased soil strength or the loss of soil structure and soil macro-porosity. Soils containing a greater clay content in combination with increased soil moisture have the highest potential for a reduction in soil porosity, soil compaction can occur down to 12” deep depending on moisture content of the soil and the type of equipment being used. Young soils with shallow soil profile depths, commonly only contain an A Horizon, are susceptible to the removal of the overlying thin A Horizon during ground based operations.

Concerns for soils in the project area include…

1) Soil cover is deficient primarily in the high and moderate soil burn severity areas and will cause hillslope erosion if additional soil cover is not generated.

2) Coarse woody debris (CWD) consumed by the fire is deficient primarily in the high and moderate soil burn severity areas.

3) Areas proposed for ground based operations on soils that are highly susceptible to a reduction of soil porosity (compaction) from heavy equipment operations during periods of increased soil moisture conditions.

4) Ground based operations on slopes greater than 35% or on shallow soils, will displace surface soil horizons that could result in accelerated erosion and/or a reduction in soil productivity.

Within the French Fire Recovery and Reforestation Project area seven individual soil families which combine to form nineteen individual soil map units (SMUs). The soil families present within the project area by dominance include the Holland, Chawanakee, Chaix, Tollhouse, Neuns and Cagwin soil families (Ginger 1993); see Table 1 for a list of the soil families and acreages. See Table 4 in Appendix A for a complete list of the soil families present within the project area and their accompanying soil profiles.

<table>
<thead>
<tr>
<th>Soil Family</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holland</td>
<td>5,339</td>
</tr>
<tr>
<td>Chawanakee</td>
<td>3,269</td>
</tr>
<tr>
<td>Chaix</td>
<td>2,215</td>
</tr>
<tr>
<td>Rock Outcrop</td>
<td>1,013</td>
</tr>
</tbody>
</table>
The soils can be categorized as one of four soil types; Entisols, Inceptisols, Mollisols or Alfisols. Entisols are the youngest of the 12 soil orders and are commonly found with only a single A Horizon overlying a C Horizon. Due to its young age very little time has occurred to allow for the formation of a mineral rich B Horizon. A less mature soil has few horizons within its profile, commonly only an A Horizon and as a result any displacement can decrease soil productivity. Those soils within the project area classified as Entisols include the Cagwin and Lithic Xeropsamments soil families.

Inceptisols are slightly older and have had enough time for the formation of a mineral B Horizon in their subsurface profile. With a greater number of soil horizons and an increased depth to bedrock, these soils are less sensitive than the younger Entisols. Soils classified as Inceptisols within the project area include the Chaix, Chawanakee Neuns soil families. Alfisols are a much older soil and have gone through a moderate amount of leaching within the soil subsurface. These soils primarily form in forests and commonly contain a subsurface horizon rich in clay. These soil types have a higher compaction risk associated to them due to the increased clay content. The only soil classified as an Alfisol is the Holland soil family.

The only Mollisol present within the project area is the Tollhouse soil family. Mollisols are commonly found with a darkly colored surface horizon with high organic matter content; base saturation is characteristically above 50% for these soils. The Tollhouse soil family doesn’t contain a B Horizon but the base saturation is between 75 and 100%, due to the higher base saturation these soils are classified as a Mollisol instead on an Entisol. Since these soils only contain an A Horizon overlying a C Horizon, displacement within the A Horizon can result in decreased soil productivity in theses soils as well.

Soil map units with the highest sensitivity to management in the project area include SUM’s 114, 119, 123, 125, 126, 148, 153 and 167. These soils are sensitive to management due to the thickness of the A Horizon, depth to bedrock and the MEH rating. The sensitivity rating is based off the potential of a soil to loose it’s productivity from ground disturbing activities and can have one of three ratings; low, moderate and high. A low sensitivity has a low potential for a loss of soil productivity under intensive use with appropriate project design measures. A moderate sensitivity has a potential for a loss of soil productivity under intensive use unless appropriate design measures are in place. A high sensitivity rating, the rating most important, has a potential loss of soil productivity under most soil disturbing activities unless other enhanced design measures are utilized. Soils with a high sensitivity are not well suited for intensive ground disturbing activities. See Table 5 for a complete list of the soil map units and their corresponding sensitivity ratings and Figure 2 for a map of the soil sensitivities within the project area.

Many land use activities have the potential to cause erosion rates to exceed natural soil erosion or soil formation rates. Accelerated erosion can lead to a reduction in soil production and can have adverse effects on water quality. If accelerated erosion continues unimpeded through time, it is likely accelerated erosion will overcome the soil formation rates. The Erosion Hazard Rating (EHR) can have one four ratings; low, moderate, high and very high.

1) Low EHR
   a. Accelerated erosion is not likely to occur
b. Adverse effects on soil productivity and nearby water quality are not expected

c. Erosion control measures are usually not needed in the areas

2) Moderate EHR

a. Accelerated erosion is likely to occur in most years

b. Adverse effects on soil productivity (especially to shallow and moderately deep soils) and nearby water quality may occur

c. Need for erosion control measures should be evaluated for these areas

3) High EHR

a. Accelerated erosion will occur in most years

b. Adverse effects on soil productivity (especially to shallow and moderately deep soils) and to nearby water quality are likely to occur

c. Erosion control is necessary for these areas to prevent accelerated erosion

4) Very High EHR

a. Accelerated erosion will occur in most years

b. Adverse effects on soil productivity and to nearby water quality are very likely to occur

c. Erosion control is essential for these areas to prevent accelerated erosion

Soil map units containing either a high or very high EHR rating include SMU’s 114, 119, 120, 123, 125, 126, 137, 139, 140, 146 and 167. Fire has altered the erosion hazard rating of the soils and the altered EHR ratings were as follows; 1,125.62 acres (Low), 6,127.76 acres (Moderate), 4,486.15 acres (High) and 15.76 acres (Very High). The high and very high EHR ratings are the most crucial concerning accelerated erosion and the loss of soil productivity. Any soils with either a high or very high EHR must contain appropriate erosion control measures to minimize the amount of accelerated erosion occurring. Soils with a low and moderate EHR still require appropriate erosion control measures as well but cause less of an impact than the high or very high ratings. See Table 7 for a complete list of the soil map units and their corresponding erosion hazard ratings and Figure 4 for a map of the soil sensitivities within the project area.

Soils intermixed with high proportions of impervious surfaces such as rock outcrop are sensitive to management because of their susceptibility to surface runoff. Sensitive soils around rock outcrops are at an increased risk of the removal of the A Horizon from possible surface runoff, generated from the rock outcrop surface. Soil map units with a rock outcrop component include SMU’s 114, 123, 126, 141, 148, 153 and 167. It is essential to have soil cover surrounding any rock outcrop to minimize the chance for accelerated erosion from occurring.

The only soil with the highest susceptibility to compaction in the project area includes the Holland soil family. Soil compaction can reduce both the soil’s aeration and its capacity to store available water (Powers 2002). Soil map units susceptible to soil compaction include SMU’s 136, 137, 138, 140, 141 and 142. These soils contain a sandy loam soil texture in the upper A Horizon transitioning to a sandy clay loam through the B Horizon down into the C Horizon at
60 inches. A higher abundance of clay minerals causes these soils to have an increased chance of compaction within the top 12 inches of the soil profile when moisture levels are above 14-15%. Most of the impact caused by ground based operations rarely causes compaction below 12 inches in the soil profile. Fire removes the protective organic layer and exposes the soil to disturbance and compaction from ground-based logging equipment (Peterson et al. 2009). Unless logging occurs when soils are dry or mitigation measures are applied, this can exacerbate erosion (Peterson et al. 2009). See Table 6 for a complete list of the soil map units and their corresponding compaction hazard rating and Figure 3 for a map of the soil sensitivities within the project area.

See the French Fire BAER Soil Report (Takenaka 2014) for a post-fire analysis of the fire effects on soil productivity.

**Desired Condition**

Thresholds and indicators have been identified to meet desired conditions for the soil resource. Use of thresholds and indicators provides a consistent method to analyze, describe and report on soil condition throughout the region.

The following desired soil conditions are applicable to the French Fire Recovery and Reforestation Project:

1. **Support for Plant Growth Function**
   a. **Soil Stability**: An adequate level of soil cover is maintained to prevent accelerated erosion, and erosion prevention measures are effectively implemented following soil disturbing activities. Effective soil cover includes organic surface materials, living vegetation less than 3 feet tall (grasses, forbs and low growing shrubs), surface rock fragments larger than ¾ inch, or where needed applied mulches.

   b. Generally on slopes less than 35%, a minimum of 50% soil cover in a well distributed pattern is needed. Greater amounts of soil cover are generally needed for steeper slopes and in riparian zones. Some soil and ecological types may not be capable of producing 50 percent soil cover because of naturally low productivity, such as areas with shallow soils, serpentinized parent material or low annual precipitation.

   c. **Surface Organic Matter**: The amount of organic material on top of the mineral soil is maintained at levels to sustain soil microorganisms and provide for nutrient cycling. The size, amount, and distribution of organic matter maintained on the mineral soil on a long term basis is consistent with the amounts that occur given the local ecological type, climate, and normal fire return interval for the area. Organic materials may range in size from amorphous and fine organic matter that makes up the O Horizon, needles and twigs, to coarser materials such as branches and logs. Generally the desired condition is most related to finer sizes of organic matter which contain the highest concentration of nutrients. It is important to note that an excess of organic matter on the mineral soil beyond the desired condition can pose a risk of adverse soil effects from fire.

   d. **Soil Organic Matter (SOM)**: The amount of organic matter within the mineral soil, indicated by the color and thickness of the upper soil horizon, is within the normal range of characteristics for the site, and is distributed normally across the area. The upper soil horizon is not displaced or eroded to the degree or extent that soil productivity is decreased for the desired vegetation.

   e. **Soil Strength**: The soil strength level is conducive to a favorable rooting environment for the desired plant species. Some level of increase in strength compared to a natural undisturbed condition may not be undesirable. Consider the findings of the Long Term Soil Productivity study and other...
current science in regard to compaction effects on fundamental soil productivity for tree growth and total biomass production. A depth range of interest for the desired plant species should be used for assessment (e.g. 4-8 inches depth).

f. Soil Moisture Regime: The inherent soil moisture regime is maintained, especially in wet meadows and fens. If needed, propose projects that will restore the soil moisture regime. During land management project analysis evaluate whether the proposed activities will result in changes to the soil moisture regime, particularly in wet meadows and fens.

2. Soil Hydrologic Function

a. Soil Stability: See desired condition description under Support for Plant Growth Function.

b. Soil Structure & Macro-porosity: Most of the area has soil structure and macro-porosity (defined here as pores 1mm or larger) that is similar to the undisturbed, natural condition for the soil type and provides sufficient infiltration and permeability to accommodate precipitation inputs for the given climate.

3. Filtering - Buffering Function

a. For projects that involve the application of chemicals, such as herbicides, pesticides, or other supplements (e.g. biosolids), analyze the effects to soil micro-organisms, post-project erosion risk, leaching potential and risk of off-site movement of the chemicals. When necessary, provide recommendations to prevent undesirable effects.

Environmental Consequences

Methodology

The ten soil transects were completed in the French Fire Recovery and Reforestation Project area to gain an overall representation of the current soil conditions. A soil transect could be classified into one of four severity classes; class 0 (natural conditions), class 1 (minor disturbance), class 2 (moderate disturbance) and class 3 (extensive disturbance). The severity class is determined by the proportion of disturbance types present along a soil transect, each individual transect point will contain a rating of zero to three for each of the seven disturbance type indicators. Disturbance type indicators include: (1) Wheel Tracks or Depressions, (2) Penetration and Resistance, (3) Soil Physical Condition, (4) Forest Floor, (5) Mineral Soil, (6) Erosion and (7) Burning. See Table 2 for a complete list of the soil disturbance types and their corresponding severity class used to determine the overall soil severity classification.

Table 2: Soil severity classifications based off the seven disturbance types

<table>
<thead>
<tr>
<th>Disturbance Type</th>
<th>Severity Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class 0</td>
</tr>
<tr>
<td>Wheel Tracks or Depressions</td>
<td>Natural conditions.</td>
</tr>
</tbody>
</table>
French Fire Recovery and Reforestation Project  
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Penetration and Resistance | Natural conditions. | Slight resistance of surface soil. | Increased resistance throughout the top 30 cm. | Increased resistance is deep into the soil profile (>30 cm).
--- | --- | --- | --- | ---
Soil Physical Condition | Natural conditions. | Change in soil structure from crumb or granular to paly in the surface (<10 cm). | Change in soil structure to greater depth (<30 cm). | Change in soil structure deep into the soil profile (>30 cm).
Forest Floor | Natural conditions. | Present and intact. | Partially missing or patchy. | Bare soil.
Mineral Soil | Natural conditions. | Soil surface has not been displaced and shows minimal mixing. | Mineral topsoil partially intact and may be mixed with subsoil. | Evidence of topsoil removal, gouging and piling. Soil displacement has removed most of the surface soil.
Erosion | Natural conditions. | Slight evidence (sheet erosion) of soil movement but some litter present. | Moderate amount of erosion evident (sheet and rill erosion). | Substantial amount of erosion evident (gullies, pedestals and rills).
Burning | Natural conditions. | Fire impacts are light. Forest floor is charred but intact. Soil surface structure intact. | Fire impacts are moderate. Litter layer is consumed and humus layer is charred or consumed. Mineral soil not visibly altered, but SOM has been partially charred | Fire impacts are deep. Entire forest floor is consumed and top layer of mineral soil is visibly altered. Surface mineral structure and texture are altered. Mineral soil is black due to charred or deposited OM or is orange from burning.

Additional site data for soil cover and shallow soil was also collected. The amount of soil cover present at each transects point is given in a percent range shallow soil was noted if the soil present at the transect point contained a profile less than 12 inches deep. Rock outcrop would be noted if any rock outcrop was observed in the immediate area. The protocol used to collect the field data came from the Forest Service Displacement Monitoring Protocol. The form used was a modified quick-transect form, which was modified because the standard protocol does not address data for soil cover percent, shallow soil, or rock outcrop. Within the nine transects completed each point evaluates seven disturbance type indicators, resulting in 70 indicator ratings being collected along each transect.

### Table 3: French Soil Transect Summary

<table>
<thead>
<tr>
<th>Soil Disturbance Class</th>
<th>65%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 0</td>
<td>10%</td>
</tr>
<tr>
<td>Class 1</td>
<td>17%</td>
</tr>
<tr>
<td>Class 2</td>
<td>8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Cover</th>
<th>17%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% Soil Cover</td>
<td>33%</td>
</tr>
<tr>
<td>&lt;20% Soil Cover</td>
<td>19%</td>
</tr>
<tr>
<td>20-50% Soil Cover</td>
<td>10%</td>
</tr>
<tr>
<td>50-80% Soil Cover</td>
<td>21%</td>
</tr>
</tbody>
</table>
Overall 65% of the soil transect points taken received a class 0 disturbance rating, 10% received a class 1 rating, 17% received a class 2 rating, and 8% received a class 3 rating. The transect points receiving class 2 and 3 disturbance ratings were mostly within the forest floor and burning disturbance indicators. Looking at soil cover 69% of the points had soil cover below 50%, this was not a surprise due to the majority of the transect points were taken in either the high or moderate soil burn severities. Within these soil burn severities, especially the high, it was a common occurrence the soil cover had been completely consumed during the fire and very little canopy remained to provide any additional soil cover. Transect points showed 80% of the points taken had slopes less than 35%, 13% had slopes within the 40 to 45% range, and 7% had slopes greater than 40%. Rock outcrop was in close proximity to 26% of transect points taken and 51% observed a shallow soil profile.

**Spatial and Temporal Context for Effects Analysis**

Direct effects on soil resources during project implementation include but are not limited to top soil disturbance potentially impacting soil organic matter, soil compaction, loss of soil cover and coarse woody debris, and accelerated erosion. Indirect effects on soil resource occur sometime after the activities take place and include but are not limited to accelerated erosion along skid trails or mastication tracks during winter storms or during the spring snowmelt, hillslope erosion, and decreased vegetation growth from compacted soils. Cumulative effects on soil resources could occur for up to 30 years after the proposed activities. All of these effects could reduce soil productivity from five to 30 years after the proposed action. The cumulative effects analysis was evaluated in the Cumulative Watershed Effects (CWE) Analysis for the French Fire Recovery and Reforestation Project (Stone 2015). The CWE Analysis considered all relevant past, present and future foreseeable actions within the project area. Effects of the proposed project will be similar to effects of recent, similar past projects implemented with current Best Management Practices and equipment that has been used in recent projects. The most recent projects on both districts include the Aspen Recovery and Restoration Project (HSRD), Greys Mountain Ecological Restoration Project (BLRD) and the East Fork Restoration Project (HSRD).

**Alternative 1: No Action**

The analysis of the no action alternative provides reviewers a baseline to compare the magnitude of environmental effects of the action alternatives and the potential long-term impacts from not implementing the Project. Under the no action alternative, salvage harvest, hazard tree removal, DFPZ creation and maintenance, SCE power line fuels treatment, invasive weed treatment, prescribed burning, and tree planting in specified treatment areas would not occur.
Current management plans would continue to guide management of the Project area, for example recreation, grazing, Burned Area Emergency Response (BAER) treatments for invasive weeds and roads, and fire suppression would continue under existing decisions and authorities. In general, existing conditions in the Project area would be driven by vegetation response to fire effects, amount of precipitation, and insect attack. Fire-affected trees would be subject to decay and breakage. High and moderate severity areas most affected by the fire would see brush and oaks sprout and brush seed scarified by heat would germinate in the spring of 2015. Surviving conifers adjacent to high and moderate severity area would cast seed. Areas of low and very low severity still dominated by conifers would see increased growth. Invasive weed treatments would not be accomplished under this Project.

**Direct & Indirect Effects (Alternative 1: No Action)**

**Soil Stability**
No direct or indirect effects associated to the no-action alternative for soil stability, no ground based activities will occur in the project area for this alternative.

**Surface & Soil Organic Matter**
No direct or indirect effects associated to the no-action alternative for surface and soil organic matter, no ground based activities will occur in the project area for this alternative.

**Soil Strength, Structure & Macro-Porosity**
No direct or indirect effects associated to the no-action alternative for soil strength, structure, and macro-porosity; no ground based activities will occur in the project area for this alternative.

**Filtering - Buffering Function**
No direct or indirect effects associated to the no-action alternative for filtering-Buffering Function; no ground based activities will occur in the project area for this alternative.

**Cumulative Effects (Alternative 1: No Action)**

**Soil Stability**
Soil structure created as a result of organic matter in the soil can easily be affected by fire for two reasons; the organic matter in a soil profile is concentrated at, or near, the surface where it is directly exposed to heating by radiation produced during the combustion of aboveground fuels and the threshold value for irreversible changes in organic matter is low (Neary et al. 2005). Soil stability altered by the fire will return to pre-fire levels once adequate soil cover has accumulated. Wildfire effects on erosion often diminish within three to six years post fire, recovery rates differ as a function of wildfire severity, rainfall intensity, vegetation type, soil type, topography and elevation (Berg & Azuma 2010).

Increased hillslope erosion is expected to occur throughout the fire area especially within those areas in the high soil burn severity. Post-fire soil water repellency breaks down within one to two years after burning and three to five years may be required before sediment yields return to background levels (Larsen et al. 2009). Until soil cover can be generated in addition to the breakdown of the hydrophobic soil layer, a negative watershed response is likely in those watersheds most heavily impacted by the fire. The burned soil surface is unprotected from raindrop impact that loosens and disperses fine soil and ash particles than can seal the soil surface and soil heating during a fire produces a water-repellent layer at or near the soil surface that further impedes infiltration into the soil (Neary et al. 2005).

Within the moderate and low soil burn severities where the canopy has not been consumed by the fire, an influx of material needed for soil cover has already occurred and will continue to occur into the future from those trees
remaining alive. However within the high soil burn severity and intermittent areas within the moderate soil burn severity, soil cover will remain at low levels until vegetation re-establishes itself within these areas. The influx of additional soil cover will also aid in the protection of not only the soil but also the ash layer if it is still present. The combination of ash and needle cast appears to be partially effective, with needles reducing the susceptibility of the ash layer to being eroded (Cerda & Stefan 2008). A thin ash layer (<1 cm) overlying a coarse or macroporous soil will clog the larger pores, increasing the hydrologic response relative to the pre-fire conditions, whereas the same ash overlying a fine or non-macroporous soil will have no effect (Woods & Balfour 2010). Additionally the ash layer may prevent significant surface runoff and erosion long enough for the recovering vegetation to provide substantial protection (Cerda & Stefan 2008). Ash layer storage increases proportionally to the ash thickness, thicker (2-5 cm) ash layers are more likely to result in the reduction or prevention of runoff (Woods & Balfour 2010).

**Surface & Soil Organic Matter**

The recovery of the surface organic matter predominately within the high soil burn severity and intermittent areas within the moderate will only occur once vegetation becomes re-established. Over long periods the inputs and outputs of forest floor materials, coarse woody debris, fine woody debris, and leaf litter eventually reach a dynamic equilibrium depending upon the stand type (Neary et al. 2005). Due to the thick duff layers present throughout the area, prolonged soil heating from smoldering duff layers increased the degree of the soil burn severity. The highest soil temperatures are reached when concentrated fuels such as slash piles and thick layers of duff burn for long periods (Neary et al. 2005). Excessive root damage is an ongoing concern in old-growth forests that have developed thick duff mounds following decades of fire exclusion (Busse et al. 2014). Within these areas of thick fuel loads soil structure was highly altered near the surface and smaller roots were charred and consumed. Soil temperatures can exceed the root lethal threshold to considerable depths in the mineral soil beneath thick duff layers (Busse et al. 2014). The re-establishment of the surface organic layer will take years to decades to return to its previous state, depending on the amount of consumption that has taken place and the influx of available material. The removal of the surface organic matter is not expected to decrease soil productivity aside from excessive erosion. Removing all surface organic matter prior to planting had no general impact on total vegetative production after 10 years (Powers et al. 2004).

Recovery of the soil organic matter predominately within the high soil burn severity will occur quicker once vegetation becomes re-established and foundation of the surface organic matter layer has occurred. Under severe burning conditions, soil organic matter can be removed or destructively altered, nutrients volatilized, water-absorbing capacity decreased, and living plant parts and microorganisms killed (Brown et al. 2003). Soil organic matter has accumulated over long time periods, decades to centuries, from root turnover and the biomass of soil organisms. In the most heavily impacted areas it can be expected the soil organic matter will take considerable time before it returns to natural conditions. However the soil organic matter wasn’t extensively altered by the fire and a loss of soil productivity isn’t expected. Fine roots where charred but still present only near the surface horizon. Loss of soil organic matter that is necessary for sustaining the biological activity of soils is the most serious long-term concern (Brown et al. 2003).

Fuel loading will be a concern in the future as snags begin to fall increasing the fire affects to the soil due to the increased fuel loads. A dead tree, from the time it dies until it is fully decomposed, contributes to many ecological processes as a standing snag and fallen woody material lying on and in the soil (Brown et al. 2003). Accumulations of large dead woody fuel, especially containing larger diameter decayed pieces, can hold smoldering fire on a site for extended periods (Brown et al. 2003). Increased fire related effects to the soil are likely to occur due to the increased fuel loads of these larger, 1,000 plus hour fuels.

**Soil Strength, Structure & Macro-Porosity**
Fire and associated soil heating can destroy soil structure, affecting both total porosity and pore size distribution in the surface horizons of a soil (Neary et al. 2005). Within a limited area of the high soil burn severity a collapse of the upper most soil layers has occurred due to the loss of the soil organic layer, resulting in a reduction in soil porosity predominately within the macropores. Through time once soil organic matter re-establishes itself within the profile, arrangement of the soil particles into soil structure will commence leading to an increase in infiltration and permeability. Additional effects of soil hydrophobicity and soil sealing on soil infiltration was previously discussed within the soil stability section.

**Filtering & Buffering Function**

No cumulative effects associated to the no-action alternative for filtering & buffering function.

**Alternative 2: Proposed Action**

Alternative 2 includes eight groups of activities that consist of: removing roadside and developed recreation site hazard trees, removing fire affected trees for economic recovery, snag retention, fuels reduction, road maintenance and construction of temporary roads and landings, reforestation treatments (site preparation, planting, and release, including the use of herbicides), and invasive weed eradication and control (including the use of herbicides). Of the 13,832 total acres within the project boundary, 7,926 acres were analyzed in detail for potential treatment; approximately 7,863 acres have some form of treatment proposed (Detailed Analysis Units). The remaining 7,867 acres have no treatments proposed due to fire severity, resource concerns, slopes greater than 35%, standard and guideline limitations on treatment, and/or no treatment is needed to meet the purpose and need.

**Design Features and Mitigation Measures**

1. Lop and scatter fuels below rock outcrops that have the potential to generate runoff into management activity areas and cause erosion, loping and scattering fuels within these areas will maximize soil cover and surface organic matter retention (USDA 2012).

2. Conduct mechanical equipment operations when the soil is sufficiently dry in the top 12 inches to prevent unacceptable loss of soil porosity (Peterson 2009; USDA 2012; & Wagenbrenner, 2015).

3. Operating out of the normal operating period during times of increased moisture content on fine textured soils, subsoiling will be required in areas where compaction has been identified. Subsoiling will be accomplished by equipment that will lift and fracture the soil by vertical and lateral shattering, leaving soil loosened through the full width and depth of the compacted layer with the topsoil remaining substantially in place rather than being inverted (Kees 2008).
   a. Subsoiling equipment will be required to utilize winged tip shanks over conventional shanks without winged tips (Kees 2008).
   b. Subsoiling depth will be determined by qualified soil scientist in the field, a lesser depth will be required if rocks or other limiting site conditions are encountered (Kees 2008).
   c. Subsoiling shall be limited to periods when soil dryness will result in crumbled soil, avoiding the formation of large clods (Kees 2008).

4. Subsoil skid trails in areas where soil compaction exceeds 15% of a treatment area (USDA 2012).

5. Excluding mastication, limit mechanical operations where sustained slopes exceed 35%, except where supported by on-the-ground interdisciplinary team evaluation (USDA 1991 & Peterson 2009).
6. Limit mastication operations to slopes less than 50%. Minimize soil displacement and reduce the risk of soil erosion by smoothing or water barreling ruts or trenches exceeding 6 inches in depth and 25 feet in length on slopes greater than 35% (BMP 5.2).

7. Soil cover needs to be maintained at an average accumulation of 50% on slopes less than 35% to minimize soil erosion and uphold surface organic matter accumulation; soil cover components include the 1 to 100-hour fuels with some 1,000 hour fuels up to 10 inch diameter. Within treated areas on slopes greater than 35%, 70% soil cover needs to be maintained. Where shrub species predominate, attempt crushing prior to piling to create small woody fragments left scattered over the site for soil cover and erosion protection (USDA 1991; Larsen 2009; & USDA, 2012).
   a. Soil cover includes ash, organic surface materials, living vegetation less than 3 feet tall (grasses, forbs and low growing shrubs), surface rock fragments larger than ¾ inch or where needed applied mulches (USDA 2012).
   b. Some soil and ecological types may not be capable of producing 50 percent soil cover because of naturally low productivity (USDA 2012).

8. Endlining within SMZs, near rock outcrops or on steeper slopes where surface gouges or trenches form water bar soil displacements if they exceed 6 inches in depth and 25 feet in length (BMP 1.9).

9. Within treatment areas that are whole-tree yared backhaul slash onto skid trails for soil cover and surface stabilization (Wagenbrenner 2014).

10. Maintain 10 to 30 tons per acre of coarse woody debris to provide desirable quantities for soil productivity and protection (Brown 2003; USDA 2004; & USDA 2012).
   a. Coarse woody debris is considered as any dead standing or downed pieces larger than 3 inches in diameter (Brown 2003).

11. After timber harvest, grapple pile, crush, jack pot burn, and/or lop and scatter on slopes greater than 25% while still maintaining fuels objectives, generated materials left behind will help achieve or maintain recommended soil cover (USDA 2004 & Peterson 2009).

12. Provide for road surface stabilization (aggregate) on roads over 5%-grade that are located on sensitive soils within a Streamside Management Zone (SMZ), and in watersheds with high Cumulative Watershed Effects (CWE) potential. Sensitive soils include; Auberry, Holland and Ultic Haploxeralfs soil families (USDA 1991).

**Direct & Indirect Effects (Alternative 2: Proposed Action)**

**Soil Stability**

In areas planned for ground based operations (i.e. skidding, tractor piling, masticating and/or grapple piling) a minimum of 50% ground cover should be maintained on the ground to prevent accelerated erosion. On slopes greater than 35%, soil cover should be maintained at 70%. Past observations on the Sierra NF in other timber operations have found this amount of soil cover generally prevents accelerated erosion from occurring. Soil cover includes organic surface materials, living vegetation less than 3 feet tall (grasses, forbs and low growing shrubs), surface rock fragments larger than ¾ inch or where needed applied mulches. Lopping and scattering around rock outcrop will prevent accelerated erosion of the adjacent soils from rapid runoff. Areas used for pile burning will have minimal effects to soil stability. Soil cover will be consumed but due to their small size and wide distribution across the landscape, the effects will be localized and negligible overall (Busse et al. 2013).
If sufficient ground cover is not maintained accelerated erosion is likely to occur, leading to a decrease in both soil productivity and water quality. The most effective way to minimize the amount of surface runoff and sediment production post-fire is to increase the amount of surface cover (Larsen et al. 2009). Within primarily all of the high soil burn severity soil cover has been completely consumed by the fire and within a small majority of the moderate soil burn severity the same conditions exist. Soils are bared by wildfire, slash produced during logging can be used to cover the soil surface and reduce erosion (Peterson et al. 2009). Ground based operations will generate excess material adding to those areas currently deficient, ground cover within the high and moderate soil burn severity is expected to increase. Salvage logging immediately increases the biomass of woody debris on the ground (Monsanto & Agee 2008). One factor that minimized the adverse effects of logging was the chopped woody debris remained on the site and protected the disturbed soils from rainfall and runoff impact (Spanos et al. 2005). However salvage removes boles that would otherwise become coarse woody debris, so one would expect lowered coarse woody debris levels decades after salvage logging compared to unsalvaged sites (Monsanto & Agee 2008).

Ground cover can be expected once vegetation re-establishes itself in the burn area, one to three years post-fire. Minimal tractor piling and grapple piling should be utilized in these areas while still maintaining fuels objectives to maximize the amount of material available for soil cover. A solid conclusion is that surface organic cover comprises the first line of defense against the erosion of surface soil (Powers 2002). The low and very low/unburned areas already meet the required 50% soil cover standard. It is essential to achieve or to come as close as possible to the amount of ground cover to minimize the amount of surface runoff and sediment production occurring in these fire affected areas.

Ground based operations will likely break up the thin layer of soil sealing and the soil hydrophobic layers, increasing soil infiltration rates and decreasing the amount of runoff and sediment generated in these areas. Effective breakup of the soil hydrophobic layers are likely to occur if the layer is between two and four inches thick and less likely if the hydrophobic layers are much thicker, greater than six inches (Poff 1989). Additional surface roughening formed by the movement of equipment across the landscape will aid in decreasing the amount of surface runoff and sediment production.

**Surface & Soil Organic Matter**

Areas within the high soil burn severity had most of the surface organic matter consumed; the moderate areas contained patchy surface organic matter and the low and very low still contained the majority of the surface organic matter. Ground operations are expected to generate excess woody debris and in those areas where the surface organic matter has been consumed, this additional material will aid in developing a new surface organic matter horizon. Organic residues are a major component of the carbon cycle that supplies an energy substrate to soil organisms that dominate soil processes; these processes control the storage and biological availability of soil water and nutrients (Powers 2002). Within the high burn severity most if not all of the canopy was consumed so the recruitment of additional surface organic matter will only occur after native vegetation has re-established itself. The moderate areas will have an influx of matter from the canopy above in those areas where the trees are still alive as well as the increase from re-established vegetation. Through time, ten to hundreds of years, the re-establishment of the surface organic matter (O Horizon) to natural levels will occur. At best, the forest floor accounts for only one-fourth of aboveground organic matter (Powers et al. 2004). Snag retention will provide ample opportunities for recruitment of additional large woody debris in areas where it is currently deficient.

Soil organic matter has accumulated over long time periods, decades to centuries, from root turnover and the biomass of soil organisms. Under severe burning conditions, soil organic matter can be removed or destructively altered, nutrients volatilized, water-absorbing capacity decreased, and living plant parts and microorganisms killed (Brown et
In the most heavily impacted areas it can be expected the soil organic matter will take considerable time before it returns to natural conditions. Loss of soil organic matter that is necessary for sustaining the biological activity of soils is the most serious long-term concern (Brown et al. 2003). However the soil organic matter wasn’t extensively altered by the fire and a loss of soil productivity isn’t expected. Only the fine roots where charred but still present near the surface horizon in the high soil burn severities and in intermittent areas within the moderate, the remaining areas still contained the majority of their roots. Soil inputs following disturbance depend less on decomposition of surface residues and more on the decay of fine roots that remained from the previously harvested stand (Powers et al. 2004).

During machine piling, either grapple or tractor piling, there is the potential for the removal of excess woody debris into machine piles for burning. Salvage removes boles that would otherwise become coarse woody debris, so one would expect lowered coarse woody debris levels decades after salvage logging compared to unsalvaged sites (Monsanto & Agee 2008). Within the high and moderate soil burn severities excess woody materials needs to be left on the ground while still maintaining fuels objectives. A minimal loss of soil organic matter within the upper A Horizon is expected during machine piling. On steeper slopes within watersheds that have a potential CWE response, grapple piling is recommended over tractor piling to minimize the amount of disturbance occurring and to maximize the amount of woody debris being left behind. In areas used for pile burning, the majority of the surface organic matter will be consumed if still present. However due to their small size and wide distribution across the landscape, the effects will be localized and negligible overall (Busse et al. 2013). Piles dominated with large woody debris (>22.5 cm diameter) tend to burn much hotter when compared to piles dominated with slash (mixed fuel sizes) (Busse et al., 2013).

Ground operations located on steeper slopes (25%-35%) where skidding may be adverse (uphill skidding) and on slopes greater than 35%, increased amounts of ground disturbance, deep ruts and/or topsoil removal, are likely to occur. Increased disturbances include complete removal of the surface organic matter and/or the mixing/removal of the surface soil horizon (A Horizon). It is recommended to end-line areas small enough were this is applicable/cost effective and to either tractor pile or grapple pile areas to minimize soil disturbance. Short sections of steep slopes for ingress and egress of the treatment units may have to be crossed with logging equipment and some soil disturbance is expected to occur.

**Soil Strength, Structure, & Macro-Porosity**

Depending on the type of equipment being used, either a tracked or rubber tired piece of equipment, the amount of soil disturbance occurring varies between the two. Wood removal methods show that tractor skidding caused significantly higher levels of soil disturbance and compaction compared to other methods such as cable skidding or use of helicopter (Spanos et al. 2005). A rubber tired tractor generates more pressure on the soil below, increasing the amount of soil disturbance (soil compaction), as the piece of equipment travels back and forth repeatedly on the same piece of ground. Whereas, a grapple piler or masticator, which is a tracked piece of equipment, generates less ground pressure, resulting in less soil disturbance. On areas above 25%, a grapple piler is recommended to minimize the amount of soil disturbance. In areas used for pile burning, the majority of the surface organic matter will be consumed along with a small proportion of the soil organic matter. Piles dominated with large woody debris (>22.5 cm diameter) tend to burn much hotter when compared to piles dominated with slash (mixed fuel sizes) (Busse et al. 2013). Due to the differences in burning intensities a change in soil texture and soil bulk density, localized to the top portion of the soil profile (10cm), is expected to occur in wood dominated piles as soil organic matter is consumed.

During times of increased soil moisture, increased extents of soils disturbance are likely to occur during skidding operations with a rubber tired skidder. Soils need soil moisture content below 14-16% to minimize detrimental soil
disturbance and/or compaction within fine textured soils. Soil moisture content at the time of harvest is a primary determinate of soil compaction and soil moisture content near field capacity is most conductive to compaction (Busse et al. 2014). Due to the forest floor consumption, especially within the high and moderate soil burn severity, additional impacts from ground based operations will occur during periods of increased soil moisture. Fire removes the protective organic layer and exposes the soil to disturbance and compaction from ground-based logging equipment (Peterson et al. 2009). Unless logging occurs when soils are dry or mitigation measures are applied, this can exacerbate erosion (Peterson et al. 2009). Compaction is a great concern in soils with a fine soil texture such as the Holland soil family and less of a concern in coarser soils such as the Chaix and Umpa soil families. Tree growth tended to be reduced by compaction on clayey soils and increased on sandy soils (Powers et al. 2004). Effects are attributed to losses of aeration porosity on clays and improvements in available water holding capacity on sands (Powers et al. 2004). A loss in soil productivity will occur in areas where sensitive soils are located during most soil disturbing activities if design measures are not followed.

Fuels reduction treatments include grapple piling, mastication and tractor piling. Tractor and grapple piling normally does not result in compacted soils during standard operating periods because it’s a tracked piece of equipment. However during times of increased soil moisture additional soil disturbance will occur if soil moisture is too high for operations. It’s recommended on steeper areas to have the grapple piler and masticator traverse the slopes parallel to the natural contour of the landscape to minimize soil displacement. Masticator equipment reduces erosion potential by increasing soil cover and generally causes little soil disturbance and compaction (Vitorelo et al. 2009). Masticating equipment normally does not result in compacted soils because the equipment has a lower ground pressure than conventional logging equipment (Vitorelo et al. 2009). In addition the masticator creates a bed of chips, not to exceed 15 inches, which acts like a carpet the masticator travels over reducing the ground pressure on the soils below. Masticators operate off skid trails and did not cause any apparent increase in the extent of detrimental compaction, this was likely due to the buffering effects of the debris bed created from the masticated materials and upon which the masticator traveled (Moghaddas & Stephens 2008). Mastication on steeper slopes will result in the formation of soil troughs where the masticator is traveling straight up or down steep slopes. These troughs could be sites of concentrated flow and could create rill and gully erosion if adequate erosion control is not provided. These troughs will be reshaped and/or adequate erosion control will be installed to prevent accelerated erosion.

Currently compaction was only evident in the legacy landings and temporary roads of past operations throughout the area. Minor changes in the soil structure and few occurrences of soil compaction occurred outside of these areas. The creation of any additional landings, temporary roads and skid trails will need appropriate erosion control measures to minimize the occurrence of accelerated erosion. Forest roads, whether built to facilitate postfire logging or not, can exacerbate hydrologic effects by concentrating and channelizing surface and subsurface flow (Peterson et al. 2009). The use of existing landings and temporary roads should be desired over the creation of any new features. Detrimental soil compaction can be curtailed by the re-use of existing skid trails and transportation networks during fuel treatments in heavily managed stands (Moghaddas & Stephens 2008). Use and reuse of designated skid trails has been highly encouraged and practiced as an option for limiting the aerial extent of site distribution (Busse et al. 2014). Some existing temporary roads and landings would be reopened and approximately 2 miles of new temporary roads and landings would be constructed for Project implementation.

**Filtering & Buffering Function**

Minimal leaching of Glyphosate is expected to occur below the six to twelve inch boundary in the soil profile. Soils with somewhat excessively drained and excessively drained drainage classifications have the highest potential for off-site movement. Utilizing buffer zones around drainages will allow for minimal effects to adjacent streams. However
due to Glyphosate’s ability to bind itself to the soil particle, soil particles suspended in runoff with Glyphosate residues attached could reach surface waters. Once there it is not readily broken down by water or sunlight.

Cumulative Effects (Alternative 2: Proposed Action)

**Soil Stability**
There is an expected net increase in soil cover throughout the project area due to ground based operations; this most needed within the high and moderate soil burn severity areas where soil cover is currently deficient. Fuels treatments will need to be minimized within these areas to maximize the availability of this material while still maintaining fuels objectives. Surface runoff is expected throughout the fire area, decreasing in extent and intensity as soil conditions change and the re-establishment of vegetation occurs.

**Surface & Soil Organic Matter**
A net increase in surface organic matter will occur throughout the project area from ground based operations, increases will be the most profound within the high and moderate soil burn severities where the majority if not all of the surface organic matter was consumed. Regeneration of the surface organic matter in those areas most affected by the fire will return to natural levels within tens to hundreds of years. The soil organic matter, which wasn't greatly affected by the fire, has accumulated from root turnover and the biomass of soil organisms. Re-establishing of soil organic matter takes considerably longer than the surface organic matter, decades to centuries before a natural level returns in those areas most greatly affected.

**Soil Strength, Structure, & Macro-Porosity**
It is expected soil compaction will not exceed 15% of the treatment area. The use of existing landings, temp roads and skid trails will help minimize the amount of additional compaction created by ground based operations. To the extent possible, subsequent harvests using heavy skidding equipment should rely on existing disturbance pathways, allowing for recovery and subsequent productivity enhancement between entries (Moghaddas Stephens 2008). Surface roughening and breaking up of the hydrophobic soil layer and soil seal will allow for increased infiltration into the soil subsurface. Increased infiltration will allow for the re-establishment of native vegetation, resulting in an increase in both surface and soil organic matter through time.

**Filtering & Buffering Function**
No cumulative effects related to repeated applications of herbicides to forest soils are known for Glyphosate (Ratcliff et al. 2006 & Busse et al. 2001).

**Alternative 3: No Herbicides**
Alternative 3 was developed in response to issues brought forward during public scoping and input from Region 5. Alternative 3 differs from alternative 2 in that no herbicides would be applied for any purpose. Management techniques for achieving the purpose and need for reforestation, DFPZs, and invasive weeds would be limited to manual or mechanical methods. All other treatments would remain the same as the proposed action.

**Design Features and Mitigation Measures**
Identical design features and mitigation measures as Alternative 2; see the design features and mitigation measures section within Alternative 2.

**Direct & Indirect Effects (Alternative 3: No Herbicides)**

**Soil Stability**
The areas proposed for ground based operations within this alternative are identical to Alternative 2; the only
difference is no herbicides will be used for reforestation and weed control. Additional mechanical methods include
blading (brush rake) and/or tilling of larger (greater than 2 feet tall), more vigorous shrub species on slopes less than
35% and on slopes greater than 35% only hand methods would be utilized. Mechanical treatments in these areas will
break up any remaining soil hydrophobic layers and any soil sealing, if present, increasing the soil infiltration rates and
decreasing the amount of hillslope erosion. Effective breakup of the soil hydrophobic layers are likely to occur if the
layer is between two and four inches thick and less likely if the hydrophobic layers are much thicker, greater than six
inches (Poff 1989).

Excess materials needed for ground cover generated during ground based operations, especially in areas where it is
deficient, could be removed from either the blading or tilling treatment. In areas where the soil cover has been
removed, increased hillslope erosion is likely to occur. It is essential to achieve the required amount of ground cover
to minimize the amount of surface runoff and sediment production occurring in the heavily impacted fire areas.
Tilling should be done along the contour of the landscape so pathways for accelerated erosion to form will be kept to
a minimum.

Implementation of soil design features and mitigation measures will cause insignificant additional direct or indirect
effects of the no herbicide treatments to soil stability from those identified within Alternative 2.

**Surface & Soil Organic Matter**
The areas proposed for ground based operations within this alternative are identical to Alternative 2; the only
difference is no herbicides will be used for reforestation and weed control. Additional mechanical methods include
blading (brush rake) and/or tilling of larger (greater than 2 feet tall), more vigorous shrub species on slopes less than
35% and on slopes greater than 35% only hand methods would be utilized. During the additional mechanical work
there is the potential of removing excess fine and woody materials needed for the re-establishment of the surface
organic matter horizon. Additional treatments on slope greater than 35% are all hand based treatments and no
additional effects to either the surface or soil organic matter will occur. Tilling isn’t expected to greatly affect the soil
organic matter; most of the organic matter will remain within the soil profile. However depending on the type of
brush rake and operator skill, undesirable amounts of topsoil displacement could occur, potentially effecting soil
organic matter (USDA 2009).

Implementation of soil design features and mitigation measures will cause insignificant additional direct or indirect
effects of the no herbicide treatments to surface & soil organic matter from those identified within Alternative 2.

**Soil Strength, Structure, & Macro-Porosity**
The areas proposed for ground based operations within this alternative are identical to Alternative 2; the only
difference is no herbicides will be used for reforestation and weed control. Additional mechanical methods include
blading (brush rake) and/or tilling of larger (greater than 2 feet tall), more vigorous shrub species on slopes less than
35% and on slopes greater than 35% only hand methods would be utilized. Additional mechanical treatments are not
proposed on slopes greater than 35%. Soils still need to have soil moisture contents below 14-16% to minimize soil
compaction when operating on fine-textured soils. Brush rakes displace less soil than a conventional straight blade
and minimizes the amount of soil disturbance occurring. Less soil disturbance leads to less soil accumulation within
the piles resulting in more complete burns. However, if not done carefully, this operation has a high potential for
creating undesirable amounts of soil disturbance, especially topsoil displacement (USDA 2009).

Implementation of soil design features and mitigation measures will cause insignificant additional direct or indirect
effects of the no herbicide treatments to soil stability from those identified within Alternative 2.
Filtering & Buffering Function
No herbicides will be used within this alternative, no direct or indirect effects associated to filtering & buffering function will occur.

Cumulative Effects (Alternative 3: No Herbicides)

Soil Stability
The areas proposed for ground based operations within this alternative are identical to Alternative 2; the only difference is no herbicides will be used for reforestation and weed control. Additional mechanical methods include blading (brush rake) and/or tilling on slopes less than 35% and on slopes greater than 35% only hand methods would be utilized. Implementation of soil design features and mitigation measures will cause insignificant additional cumulative effects of the no herbicide treatments to soil stability from those identified within Alternative 2.

Surface & Soil Organic Matter
The areas proposed for ground based operations within this alternative are identical to Alternative 2; the only difference is no herbicides will be used for reforestation and weed control. Additional mechanical methods include blading (brush rake) and/or tilling on slopes less than 35% and on slopes greater than 35% only hand methods would be utilized. Implementation of soil design features and mitigation measures will cause insignificant additional cumulative effects of the no herbicide treatments to surface & soil organic from those identified within Alternative 2.

Soil Strength, Structure, & Macro-Porosity
The areas proposed for ground based operations within this alternative are identical to Alternative 2; the only difference is no herbicides will be used for reforestation and weed control. Additional mechanical methods include blading (brush rake) and/or tilling on slopes less than 35% and on slopes greater than 35% only hand methods would be utilized. Implementation of soil design features and mitigation measures will cause insignificant additional cumulative effects of the no herbicide treatments to soil strength, structure, & macro-porosity from those identified within Alternative 2.

Filtering & Buffering Function
No herbicides will be used within this alternative, no cumulative effects associated to filtering & buffering function will occur.

Alternative 4: Hazard Tree and Plantation Salvage Only
Alternative 4 reflects the public’s concern for salvage logging in moderate to high burn severities and treatments in proximity to California Spotted Owl Protected Activity Centers (PACs). This alternative differs in salvage treatments from Alternative 2 because it would only remove roadside and developed recreation site hazard trees and harvest salvage trees within plantation units only that are greater than 1.5 kilometer (circular area) from California Spotted Owl PACs.

The other proposed treatments for snag retention, roads, DFPZ, SCE’s power line right-of-way, and noxious weeds would be the same as alternative 2; although the acres of overlapping treatments differ.

Design Features and Mitigation Measures
Identical design features and mitigation measures as Alternative 2; see design features and mitigation measures section in Alternative 2.

Direct & Indirect Effects (Alternative 4: Hazard Tree and Plantation Salvage Only)
Soil Stability
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional direct or indirect effects within these treatments areas to soil stability from those identified within Alternative 2 will occur.

Surface & Soil Organic Matter
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional direct or indirect effects to surface & soil organic matter from those identified within Alternative 2 will occur.

Soil Strength, Structure, & Macro-Porosity
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional direct or indirect effects to soil strength, structure, & macro-porosity from those identified within Alternative 2 will occur.

Filtering & Buffering Function
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional direct or indirect effects to filtering & buffering function from those identified within Alternative 2 will occur.

Cumulative Effects (Alternative 4: Hazard Tree and Plantation Salvage Only)
Soil Stability
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional cumulative effects within these treatments areas to soil stability from those identified within Alternative 2 will occur.

Surface & Soil Organic Matter
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional cumulative effects within these treatments areas to surface & soil organic matter from those identified within Alternative 2 will occur.

Soil Strength, Structure, & Macro-Porosity
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional cumulative effects within these treatments areas to soil strength, structure, & macro-porosity from those identified within Alternative 2 will occur.

Filtering & Buffering Function
The areas proposed for ground based operations within this alternative are limited to only the roadside and plantations. No additional cumulative effects within these treatments areas to filtering & buffering function from those identified within Alternative 2 will occur.

Alternative 5: No Secondary Entry
The difference between alternative 5 and alternative 2 is that fire affected trees would be removed and harvested on approximately 1,946 acres in moderate to high burn severity as the only salvage entry. 910 acres of low to moderate burn severity would not be treated. Units u33m (4 acres) and u53m (4 acres) would not be treated so that patches of 10 acres or less would not be treated in high severity areas. Units u47m (5 acres), u453m (23 acres) and portions of
u52m (9 acres) would not be treated because they fall within 1 km circular area of CSO PAC MAD45 in which less than 32% of the territory burned at high severity.

The other proposed treatments for snag retention, roads, DFPZ, SCE’s power line right-of-way, and noxious weeds would be the same as alternative 2; although, the acres of overlapping treatments differ

**Design Features and Mitigation Measures**
Identical design features and mitigation measures as Alternative 2; see design features and mitigation measures section in Alternative 2.

**Direct & Indirect Effects (Alternative 5: No Secondary Entry)**

**Soil Stability**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional direct or indirect effects within the remaining treatment areas to soil stability from those identified within Alternative 2 will occur.

**Surface & Soil Organic Matter**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional direct or indirect effects within the remaining treatment areas to surface & soil organic matter from those identified within Alternative 2 will occur.

**Soil Strength, Structure, & Macro-Porosity**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional direct or indirect effects within the remaining treatment areas to soil strength, structure, & macro-porosity from those identified within Alternative 2 will occur.

**Filtering & Buffering Function**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional direct or indirect effects within the remaining treatment areas to filtering & buffering function from those identified within Alternative 2 will occur.

**Cumulative Effects (Alternative 5: No Secondary Entry)**

**Soil Stability**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional cumulative effects within the remaining treatments areas to soil stability from those identified within Alternative 2 will occur.

**Surface & Soil Organic Matter**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional cumulative effects within the remaining treatments areas to surface & soil organic matter from those identified within Alternative 2 will occur.

**Soil Strength, Structure, & Macro-Porosity**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional cumulative effects within the
remaining treatments areas to soil strength, structure, & macro-porosity from those identified within Alternative 2 will occur.

**Filtering & Buffering Function**
The areas proposed for ground based operations within this alternative are somewhat identical to Alternative 2; the only difference is the entry into the secondary units will not occur. No additional cumulative effects within the remaining treatments areas to filtering & buffering function from those identified within Alternative 2 will occur.

**Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans**
Compliance with the SNF LRMP Management Standard and Guidelines is built into the design measures of the project. As documented in the effects analysis, alternatives 2, 3, 4, and 5 will minimize tractor logging on steep slopes with high erosion hazard, erosion control measures will be applied appropriately, ground cover and coarse woody debris will be sufficiently distributed across the landscape, if insufficient snag retention provides ample opportunities for coarse woody debris recruitment. With implementation of the project design features, alternatives 2, 3, 4, and 5 are in full compliance of the National Forest Management Act of 1976, the Forest Service Manual (FSM) 2500 – Watershed and Air Management, and the Sierra National Forest Plan and Amendments.

**Monitoring Recommendations**
Monitoring of soil conditions would be conducted on a selection of activity areas to determine if soil standard and guidelines and soil management objectives are being met. Nine soil transects have been established in the French Fire Recovery and Reforestation Project area to determine existing soil conditions. After implementation has completed, additional soil transects within the treatment units needs to be completed. Monitoring would be accomplished in accordance with the National Forest Soil Disturbance Monitoring Protocol (USDA Forest Service, 2009).

Soil monitoring would be conducted along transects according to the protocol after the proposed treatments. Soil monitoring should be designed to determine the extent of detrimental soil compaction from mechanical treatments. Soil cover should be determined from both mechanical treatment and prescribed fire (if applicable). Timing for conducting post-treatment soil transects is important to determine soil cover generated during ground based operations, especially soil cover condition going into the following winter.
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### Appendix A

#### Table 4: French soil families

<table>
<thead>
<tr>
<th>Soil Family</th>
<th>Taxonomy Name</th>
<th>Temp. Regime</th>
<th>Texture</th>
<th>Hyd Grp</th>
<th>Drainage Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cagwin</td>
<td>Dystric Xeropsamments</td>
<td>Frigid</td>
<td>A: 0 to 5 inches, loamy coarse sand</td>
<td>A</td>
<td>Somewhat Excessively Drained</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C: 5 to 17 inches, gravelly loamy coarse sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chaix</td>
<td>Dystric Xerochrepts</td>
<td>Frigid</td>
<td>A: 0 to 6 inches, coarse sandy loam</td>
<td>B</td>
<td>Somewhat Excessively Drained</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bw1: 6 to 18 inches, coarse sandy loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bw2: 18 to 36 inches, gravelly coarse sandy loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cr: 36 inches, highly weathered granodiorite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chawanakee</td>
<td>Dystric Xerochrepts</td>
<td>Mesic</td>
<td>A: 0 to 4 inches, coarse sandy loam</td>
<td>C</td>
<td>Somewhat Excessively Drained</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bw: 4 to 19 inches, coarse sandy loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cr: 19 inches, highly weathered granodiorite that breaks down to very</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>gravelly loamy coarse sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holland</td>
<td>Ultic Haploxeralfs</td>
<td>Mesic</td>
<td>A1: 0 to 3 inches, sandy loam</td>
<td>B</td>
<td>Well drained</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AB: 3 to 7 inches, sandy loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AB: 7 to 14 inches, light sandy clay loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BA: 14 to 25 inches, sandy clay loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bt1: 25 to 34 inches, clay loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bt2: 34 to 51 inches, sandy clay loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bt3: 51 to 60 inches, sandy clay loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C: 60 to 66 inches, sandy loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lithic</td>
<td>Lithic Xeropsamments</td>
<td>Frigid</td>
<td>A1: 0 to 4 inches, gravelly loamy coarse sand</td>
<td>D</td>
<td>Excessively Drained</td>
</tr>
<tr>
<td></td>
<td>Xeropsamments</td>
<td></td>
<td>A2: 4 to 9 inches, gravelly loamy coarse sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C: 9 to 11 inches, gravelly loamy coarse sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R: 11 inches, unweathered granodiorite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuns</td>
<td>Dystric Xerochrepts</td>
<td>Mesic</td>
<td>A: 0 to 7 inches, gravelly loam</td>
<td>B</td>
<td>Well Drained</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bw1: 7 to 13 inches, gravelly loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bw2: 13 to 35 inches, cobbly loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bw3: 25 to 45 inches, very cobbly loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C1: 45 to 54 inches, extremely cobbly loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2r: 54 inches, highly weathered &amp; fractured metasedimentary rock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tollhouse</td>
<td>Entic Haploxerolls</td>
<td>Mesic</td>
<td>A1: 0 to 11 inches, gravelly coarse sandy loam</td>
<td>D</td>
<td>Somewhat Excessively Drained</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A2: 11 to 18 inches, gravelly coarse sandy loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cr: 18 inches, weathered quartz diorite</td>
<td></td>
<td></td>
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</table>
### Table 5: French soil map units and their associated soil sensitivity rating

<table>
<thead>
<tr>
<th>Soil Map Unit</th>
<th>Soil Map Unit Name</th>
<th>Soil Sensitivity Rating</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>114</td>
<td>Cagwin Family-Lithic Xeropsammments-Rock Outcrop Complex, 45 to 65 Percent Slopes</td>
<td>High</td>
<td>141.348</td>
</tr>
<tr>
<td>119</td>
<td>Chaix Family, 35 to 65 Percent Slopes</td>
<td>Moderate and High</td>
<td>521.031</td>
</tr>
<tr>
<td>120</td>
<td>Chaix Family, deep, 5 to 45 Percent Slopes</td>
<td>Low and Moderate</td>
<td>371.342</td>
</tr>
<tr>
<td>121</td>
<td>Chaix Family-Chaix family, deep Complex, 15 to 50 Percent Slopes</td>
<td>Moderate</td>
<td>30.6623</td>
</tr>
<tr>
<td>123</td>
<td>Chaix-Chawanakee Families-Rock Outcrop Complex, 35 to 65 Percent Slopes</td>
<td>Moderate and High</td>
<td>1.93242</td>
</tr>
<tr>
<td>124</td>
<td>Chaix-Holland Families Complex, 15 to 35 Percent Slopes</td>
<td>Moderate</td>
<td>388.559</td>
</tr>
<tr>
<td>125</td>
<td>Chaix-Holland families Complex, 35 to 65 Percent Slopes</td>
<td>Moderate and High</td>
<td>901.14</td>
</tr>
<tr>
<td>126</td>
<td>Chawanakee Family-Rock Outcrop Complex, 35 to 65 Percent Slopes</td>
<td>High</td>
<td>3269.17</td>
</tr>
<tr>
<td>136</td>
<td>Holland family, 5 to 35 Percent Slopes</td>
<td>Low</td>
<td>1280.77</td>
</tr>
<tr>
<td>137</td>
<td>Holland Family, 35 to 65 Percent Slopes</td>
<td>Moderate</td>
<td>646.77</td>
</tr>
<tr>
<td>138</td>
<td>Holland-Chaix families Complex, 5 to 35 Percent Slopes</td>
<td>Low</td>
<td>292.254</td>
</tr>
<tr>
<td>139</td>
<td>Holland-Chaix families Complex, 35 to 65 Percent Slopes</td>
<td>Moderate</td>
<td>20.2742</td>
</tr>
<tr>
<td>140</td>
<td>Holland-Chawanakee families Complex, 35 to 65 Percent Slopes</td>
<td>Moderate</td>
<td>420.348</td>
</tr>
<tr>
<td>141</td>
<td>Holland-Chawanakee families-Rock Outcrop Complex, 15 to 35 Percent Slopes</td>
<td>Low</td>
<td>1184.62</td>
</tr>
<tr>
<td>142</td>
<td>Holland-Neuns families Association, 15 to 45 Percent Slopes</td>
<td>Low and Moderate</td>
<td>1493.56</td>
</tr>
<tr>
<td>146</td>
<td>Neuns Family, 25 to 60 Percent Slopes</td>
<td>Low and Moderate</td>
<td>896.402</td>
</tr>
<tr>
<td>148</td>
<td>Rock Outcrop-Chawanakee Family Association, 35 to 65 Percent Slopes</td>
<td>High</td>
<td>966.203</td>
</tr>
<tr>
<td>153</td>
<td>Rock Outcrop-Lithic Xeropsammments Complex, 45 to 85 Percent Slopes</td>
<td>High</td>
<td>46.3997</td>
</tr>
<tr>
<td>167</td>
<td>Tollhouse Family-Rock Outcrop Association, 60 to 85 Percent Slopes</td>
<td>High</td>
<td>960.578</td>
</tr>
<tr>
<td>WAT</td>
<td>None</td>
<td>None</td>
<td>1.8038</td>
</tr>
</tbody>
</table>
### Table 6: French soil map units and their associated soil compaction hazard rating

<table>
<thead>
<tr>
<th>Soil Map Unit</th>
<th>Soil Map Unit Name</th>
<th>Soil Compaction Hazard</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>114</td>
<td>Cagwin Family-Lithic Xeropsamments-Rock Outcrop Complex, 45 to 65 Percent Slopes</td>
<td>Low</td>
<td>141.348</td>
</tr>
<tr>
<td>119</td>
<td>Chaix Family, 35 to 65 Percent Slopes</td>
<td>Low</td>
<td>521.031</td>
</tr>
<tr>
<td>120</td>
<td>Chaix Family, deep, 5 to 45 Percent Slopes</td>
<td>Low</td>
<td>371.342</td>
</tr>
<tr>
<td>121</td>
<td>Chaix Family-Chaix family, deep Complex, 15 to 50 Percent Slopes</td>
<td>Low</td>
<td>30.6623</td>
</tr>
<tr>
<td>123</td>
<td>Chaix-Chawanakee Families-Rock Outcrop Complex, 35 to 65 Percent Slopes</td>
<td>Low</td>
<td>1.93242</td>
</tr>
<tr>
<td>124</td>
<td>Chaix-Holland Families Complex, 15 to 35 Percent Slopes</td>
<td>Low</td>
<td>388.559</td>
</tr>
<tr>
<td>125</td>
<td>Chaix-Holland families Complex, 35 to 65 Percent Slopes</td>
<td>Low</td>
<td>901.14</td>
</tr>
<tr>
<td>126</td>
<td>Chawanakee Family-Rock Outcrop Complex, 35 to 65 Percent Slopes</td>
<td>Low</td>
<td>3269.17</td>
</tr>
<tr>
<td>136</td>
<td>Holland family, 5 to 35 Percent Slopes</td>
<td>High</td>
<td>1280.77</td>
</tr>
<tr>
<td>137</td>
<td>Holland Family, 35 to 65 Percent Slopes</td>
<td>High</td>
<td>646.77</td>
</tr>
<tr>
<td>138</td>
<td>Holland-Chaix families Complex, 5 to 35 Percent Slopes</td>
<td>High</td>
<td>292.254</td>
</tr>
<tr>
<td>139</td>
<td>Holland-Chaix families Complex, 35 to 65 Percent Slopes</td>
<td>High</td>
<td>20.2742</td>
</tr>
<tr>
<td>140</td>
<td>Holland-Chawanakee families Complex, 35 to 65 Percent Slopes</td>
<td>High</td>
<td>420.348</td>
</tr>
<tr>
<td>141</td>
<td>Holland-Chawanakee families-Rock Outcrop Complex, 15 to 35 Percent Slopes</td>
<td>High</td>
<td>1184.62</td>
</tr>
<tr>
<td>142</td>
<td>Holland-Neuns families Association, 15 to 45 Percent Slopes</td>
<td>High</td>
<td>1493.56</td>
</tr>
<tr>
<td>146</td>
<td>Neuns Family, 25 to 60 Percent Slopes</td>
<td>Low</td>
<td>896.402</td>
</tr>
<tr>
<td>148</td>
<td>Rock Outcrop-Chawanakee Family Association, 35 to 65 Percent Slopes</td>
<td>None</td>
<td>966.203</td>
</tr>
<tr>
<td>153</td>
<td>Rock Outcrop-Lithic Xeropsamments Complex, 45 to 85 Percent Slopes</td>
<td>None</td>
<td>46.3997</td>
</tr>
<tr>
<td>167</td>
<td>Tollhouse Family-Rock Outcrop Association, 60 to 85 Percent Slopes</td>
<td>Low</td>
<td>960.578</td>
</tr>
<tr>
<td>WAT</td>
<td>None</td>
<td>None</td>
<td>1.8038</td>
</tr>
</tbody>
</table>
Table 7: French soil map units and their associated erosion hazard rating

<table>
<thead>
<tr>
<th>Soil Map Unit</th>
<th>Soil Map Unit Name</th>
<th>Erosion Hazard Rating</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>114</td>
<td>Cagwin Family-Lithic Xeropsamments-rock outcrop complex , 45 to 65 percent slopes</td>
<td>High</td>
<td>61.1182</td>
</tr>
<tr>
<td>114</td>
<td>Cagwin Family-Lithic Xeropsamments-rock outcrop complex , 45 to 65 percent slopes</td>
<td>Moderate</td>
<td>80.2294</td>
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<td>119</td>
<td>Chaix Family, 35 to 65 percent slopes</td>
<td>High</td>
<td>276.936</td>
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<tr>
<td>119</td>
<td>Chaix Family, 35 to 65 percent slopes</td>
<td>Moderate</td>
<td>244.094</td>
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<td>120</td>
<td>Chaix Family, deep, 5 to 45 percent slopes</td>
<td>High</td>
<td>82.3789</td>
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<td>120</td>
<td>Chaix Family, deep, 5 to 45 percent slopes</td>
<td>Moderate</td>
<td>288.964</td>
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<tr>
<td>121</td>
<td>Chaix Family-chaix family, deep complex, 15 to 50 percent slopes</td>
<td>Moderate</td>
<td>30.6623</td>
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<tr>
<td>123</td>
<td>Chaix-Chawanakee Families-Rock Outcrop complex, 35 to 65 percent slopes</td>
<td>High</td>
<td>0.260794</td>
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<tr>
<td>123</td>
<td>Chaix-Chawanakee Families-Rock Outcrop complex, 35 to 65 percent slopes</td>
<td>Moderate</td>
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<td>124</td>
<td>Chaix-Holland Families complex, 15 to 35 percent slopes</td>
<td>Low</td>
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<td>124</td>
<td>Chaix-Holland Families complex, 15 to 35 percent slopes</td>
<td>Moderate</td>
<td>165.911</td>
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<td>125</td>
<td>Chaix-Holland families complex, 35 to 65 percent slopes</td>
<td>High</td>
<td>571.642</td>
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<td>Chaix-Holland families complex, 35 to 65 percent slopes</td>
<td>Moderate</td>
<td>329.497</td>
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<td>126</td>
<td>Chawanakee Family-Rock Outcrop complex, 35 to 65 percent slopes</td>
<td>High</td>
<td>2013.05</td>
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<tr>
<td>126</td>
<td>Chawanakee Family-Rock Outcrop complex, 35 to 65 percent slopes</td>
<td>Moderate</td>
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<td>136</td>
<td>Holland family, 5 to 35 percent slopes</td>
<td>Low</td>
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<td>Holland family, 5 to 35 percent slopes</td>
<td>Moderate</td>
<td>627.037</td>
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<td>Holland Family, 35 to 65 percent slopes</td>
<td>High</td>
<td>398.724</td>
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<td>Holland Family, 35 to 65 percent slopes</td>
<td>Moderate</td>
<td>248.046</td>
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<td>Holland-Chaix families complex, 5 to 35 percent slopes</td>
<td>Low</td>
<td>146.124</td>
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<td>Moderate</td>
<td>146.13</td>
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<td>High</td>
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<td>12.8</td>
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<td>140</td>
<td>Holland-Chawanakee families complex, 35 to 65 percent slopes</td>
<td>High</td>
<td>420.348</td>
</tr>
<tr>
<td>141</td>
<td>Holland-Chawanakee families-Rock outcrop complex, 15 to 35 percent slopes</td>
<td>Moderate</td>
<td>1184.62</td>
</tr>
<tr>
<td>142</td>
<td>Holland-Neuns families association, 15 to 45 percent slopes</td>
<td>Low</td>
<td>324.959</td>
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<td>Holland-Neuns families association, 15 to 45 percent slopes</td>
<td>Moderate</td>
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<tr>
<td>146</td>
<td>Neuns Family, 25 to 60 percent slopes</td>
<td>High</td>
<td>662.407</td>
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<td>146</td>
<td>Neuns Family, 25 to 60 percent slopes</td>
<td>Moderate</td>
<td>233.995</td>
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<td>148</td>
<td>Rock Outcrop-Chawanakee Family association, 35 to 65 percent slopes</td>
<td>None</td>
<td>966.203</td>
</tr>
<tr>
<td>153</td>
<td>Rock Outcrop-Lithic Xeropsamments complex, 45 to 85 percent slopes</td>
<td>None</td>
<td>46.3997</td>
</tr>
<tr>
<td>167</td>
<td>Tollhouse Family-Rock Outcrop association, 60 to 85 percent slopes</td>
<td>Moderate</td>
<td>944.819</td>
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<tr>
<td>167</td>
<td>Tollhouse Family-Rock Outcrop association, 60 to 85 percent slopes</td>
<td>Very High</td>
<td>15.7593</td>
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<tr>
<td>WAT</td>
<td>None</td>
<td>None</td>
<td>1.8038</td>
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</table>
Figure 1: Soil Burn Severity Map
Figure 2: Soil Sensitivity Rating Map
Figure 3: Soil Compaction Hazard Rating Map
Figure 4: Soil Erosion Hazard Rating Map