SOIL SPECIALIST REPORT
Eiler Fire Salvage and Restoration Project

Lassen National Forest
Hat Creek Ranger District
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Executive Summary

The Eiler Fire Salvage and Restoration Project (Eiler Project) would comply with the Lassen National Forest Resource Management Plan standards for long-term soil productivity. The proposed salvage and fuel treatments in each alternative are not expected to adversely affect soil resources because of design criteria that will be implemented as part of each management alternative. These design criteria will help to ensure that resource safeguards will be in place that would prevent adverse effects on the soil resource from occurring.

INTRODUCTION

This report provides an analysis of the effects of the Eiler Project on soil quality in the project area.

The report describes the soils in the project area, provides an assessment of current soil conditions, and analyzes the potential effects that treatments under the proposed action might have on the soil resource.

The report includes:

- applicable standards and guidelines that were used to evaluate soil condition and potential impacts of proposed treatments;
- a description of the methods used to assess the effects of the project on soils;
- a description of the affected environment, including soils of the project area, their mapped distribution, and assessment of their current condition as affected by past management activities and wildfire; and
- an assessment of the direct, indirect, and cumulative effects of the proposed action on the soil resource;

Standards and guidelines

Applicable standards and guidelines for soil quality are provided by the Lassen National Forest Land and Resource Management Plan (1993) and the Sierra Nevada Forest Plan Amendment (2004). See Appendix A for a complete list of standards and guidelines for soil productivity.

METHODS

SOIL RESOURCE INFORMATION

General soils information for the project area was obtained from Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, and the Soil Survey Geographic (SSURGO) Database for Lassen National Forest and Intermountain Area. Accessed January 2015. Available online at http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. This soil information includes soil maps, map unit descriptions, information on soil properties, hydrologic soil groups, and soil interpretations.

SOIL EROSION HAZARD RATING

The California Soil Survey Committee Erosion Hazard Rating (EHR) System (CSSC, 2001) was used to rate the risk of soil erosion for all soils in the project area. This system uses various physical soil properties along with climate and site-specific conditions to rate soils for hazard of sheet and rill erosion. The rating method was modified to include the hydrological effects of soil burn severity.

SOIL COMPACTION RISK RATING

The Region 5 Detrimental Compaction Risk Rating Guide (Roath, 2006) was used to rate the risk of compaction for soils in the project area. This rating guide uses soil texture and rock fragment content, as determined in the field, to determine the inherent physical risk of compaction for a given soil.

POST-FIRE BAER ASSESSMENT

Wildfire effects on the soils were assessed by the Eiler Fire Burned Area Emergency Response (BAER) Team. The BAER assessment area included all of the Eiler Project area. Effects interpretation relies upon assessment of soil burn severity, and rating of erosion hazard. It is important to note that BAER assessment is a *rapid* assessment process; due to the rapid nature, it is not intended or expected to be entirely comprehensive and accurate. It is however a quality assessment of overall post-fire conditions and fire effects on the soils, and mapping products are geographically accurate in most of the area.

Soil Burn Severity (SBS) is a summary rating of post-fire soil condition, used for the purpose of rapidly stratifying the burn area, identifying source areas of greater potential for runoff and erosion, and assisting other resource specialists in prioritizing where to spend limited field time. SBS is an integrative indicator of aboveground *and* belowground fire effects, not merely a vegetative mortality rating. SBS is also used to identify potential treatment areas to prevent potential ‘emergencies’ as defined by the BAER process.

SBS was mapped and field verified; methodology followed Parsons (2010). The following are simplified descriptions of the ratings. Low SBS has a mosaic underburn with good overstory survival, so acceptable canopy cover remains for the soil; soils have little heat penetration and should continue to function normally; soil cover remains largely intact. Moderate SBS has high understory consumption along with high to complete overstory mortality; the ‘brown crowns’ are not all consumed however, so dead foliage is present in portions of moderate SBS areas to provide soil cover in the form of needlecast in the short term; up to 80 percent of litter and duff may have been consumed; soils have moderate heat penetration but should recover adequately after a modest potential for first-year erosion. High SBS has complete understory consumption and overstory mortality, with crown foliage consumed and no potential soil cover; soils have hotter and deeper heat penetration, with partial destruction of soil organic matter and surface structure; infiltration is affected and erosion potential elevated for four to five years post-fire.

FIELD OBSERVATIONS

The Lassen National Forest (LNF) soil scientist and two other soil scientists made field observations as members of the Day-Bald-Eiler Fires BAER team August 16-24, 2014. The BAER soil assessment methodology is discussed above.

In addition to the field work conducted by the BAER team soil scientists, the Eiler Project area was visited by the LNF soil scientist during the fall and winter of 2014-15. The purposes of field work were to: (1) validate the Soil Survey mapping, (2) gather information on site-specific soil properties, (3) assess current soil conditions as affected by past management activities and wildfire, and (4) develop predictions on soil response to the proposed treatments.

The Eiler Project area was visited by the LNF soil scientist on 11/12/2014, 11/14/2014, 11/24/2014, 11/25/2014, 1/30/15 and 2/4/15. Field work consisted of walk-through inspections in various units and soil monitoring along five transects in Units 202, 213, and 313 following the national soils monitoring protocol (Page-Dumroese, 2009). In addition, soils data collected for the Whittington Project in 2011 at a location that is now part of the Eiler Project is utilized here.

AFFECTED ENVIRONMENT

GEOLOGY AND SOILS

The project area is located on the east side of the southern Cascade Mountains. See the Eiler Environmental Assessment for a description of the project geography.

Soil parent materials in the project activity areas are from various volcanic sources: basalt, andesite, rhyolite, cinder, and tephra. To simplify the analysis soil map units comprising less than 0.5 acre total were eliminated from consideration. Soils and underlying rock are generally porous, causing precipitation to percolate deeply rather than contribute to streamflow. This is evidenced by the lack of perennial streams in the project interior and few seasonal streams.

Several cinder cones are located within the analysis area, including Twin Buttes, and unnamed features that have cinder pits. Management direction is to prohibit tractor logging on cinder cone slopes greater than 20 percent.

The dominant soil surface texture is sandy loam with varying rock contents, covering about 64 percent of the project area. Rock dominates about 30 percent of the project area surface while a much smaller area is comprised of loams (5 percent) and clays (0.6 percent). These predominantly coarse and rocky soils tend to be more suitable for mechanical operations than finer–textured soils.

Erosion hazard rating (EHR) is dependent on slope, texture, depth, and soil cover; rock fragments >3/4 inch count for cover on bare soil. Over 85 percent of the ground-based project activity area is dominated by soils with at least 15 percent rock in the surface soil, and of that

over a third of the area has more than 35 percent rock cover. Post-fire estimates of rock cover at 117 observation points in the Eiler proposed action units indicate a rock cover of approximately 24 percent. Following wildfire rock cover is very important to the protection of soils from erosion since the other soil cover, the forest floor and low-growing vegetation are largely gone. EHR is calculated here assuming bare soil conditions to reflect maximum EHR associated with moderate and high burn severity areas where little soil cover remains. See Appendix B for the table of soils in the project mechanical activity areas and their erosion hazard ratings, and Appendix C for subsoil characteristics and their compaction hazard ratings.

No hillslope treatments for resource protection were determined to be necessary in the Eiler Fire BAER Assessment (Day-Bald-Eiler BAER Soil Report, 2014).

CURRENT SOIL CONDITIONS

Factors influencing current soil condition are soil type, residual effects of past management, and recent wildfire effects. The assessment of current soil condition is based on field observations, the BAER assessment, and an evaluation of past logging activities in the project area.

WILDFIRE EFFECTS

The Eiler Fire burned 14926 acres on the Lassen National Forest. Approximately 37 percent of the area burned at very low to low SBS, 60 percent burned at moderate SBS, and 2 percent at high SBS. The high and moderate SBS classes have evidence of severe soil heating in a patchy distribution. Despite widespread complete vegetative mortality, there was an overall lack of high soil burn severity (SBS) due to rapid fire progression and thus short residence time for severe soil heating effects. The seedbank and infiltration characteristics are largely intact for the moderate SBS, so natural recovery should be normal and acceptable for the resource. The low and lesser severity classes still have good surface structure, contain intact fine roots and organic matter, and should recover in the short-term once revegetation begins and the soil surface regains cover.

Water repellency is a phenomenon of some dry soils in which water is very slow to infiltrate into the soil profile. The condition is commonly exacerbated by wildfires and is evaluated as part of the BAER assessment. within the Eiler Fire water repellency was common, varying from slight and surficial in low SBS to severe at two to four inches depth in high SBS; repellency was generally patchy everywhere, so it is not expected to greatly exacerbate runoff production. Unburned areas had little repellency. These sandy loam soils generally have rapid infiltration rates, so surface runoff and erosion should be localized to shallow soil areas upon steep, sparsely-vegetated slopes. While there is generally little potential for sediment delivery to the fluvial system due to somewhat unique geology in this vicinity, significant overland flows and sediment deposition have recently been observed south of Dutch Flat as a result of erosion and runoff from steep, rhyolitic slopes on the north face of Cornaz Peak.

Desired Condition

The National Forest Management Act of 1976 (NFMA, 1976) recognized the fundamental need to protect, and where appropriate improve, the quality of soil. NFMA requires that the Forest Service manage lands so as not to impair their long-term productivity. Further, activities must be monitored to ensure that productivity is protected. NFMA led to subsequent regulation and policy to execute the law at various levels of management.

The National Soil Management Manual (USFS, 2010) defines soil productivity and components of soil productivity, and establishes guidance for measuring soil productivity. In determining a significant change in productivity, a 15 percent reduction in inherent soil productivity potential will be used as a basis for threshold values. Developed at the Regional and Forest levels, these thresholds are known as Soil Quality Standards.

The management direction in the Land and Resource Management Plan for the Lassen National Forest (LRMP, 1993), the Sierra Nevada Forest Plan Amendment Record of Decision, (SNFPA 2004), and LNF Forest Supervisor directive dated June 11, 2007, provide the following soil quality standards. These standards constitute the immediate foreseeable and long-term desired condition for the Eiler Project:

- The areal extent of detrimental soil disturbance will not exceed 15 percent of the area dedicated to growing vegetation. (LRMP, 1993, p. 4-27)

- Soil cover is sufficient to prevent the rate of accelerated soil erosion from exceeding the rate of soil formation. (LRMP, 1993, p. 4-27)

- Soil porosity is at least 90 percent of the measurements found under undisturbed or natural conditions. (Tippin, 2007)

- Organic matter is present in amounts sufficient to prevent significant short or long-term nutrient cycle deficits. (LRMP, 1993, p. 4-27)

- Soil organic matter in the upper 12 inches of soil is at least 85 percent of the total soil organic matter found under undisturbed or natural conditions. (LRMP, 1993, p. 4-27)

- Litter and duff occurs on at least 50 percent of the area. (LRMP, 1993, p. 4-27)
- Large woody material (LWM), when occurring in the forested area, is at least five logs per acre in contact with the soil surface; and represents the total range of decomposition. (LRMP, 1993, p. 4-27)

- Restore all substantial areas of significantly degraded soil. (LRMP, 1993, p. 4-27)

CURRENT STATUS OF INDICATORS

Soil Cover (for erosion prevention): Loss of soil cover from the wildfire is the primary soil concern identified in the proposed activity area, with the consequence of elevated erosion

potential. The units that experienced moderate or high soil burn severity (SBS) were without organic soil cover immediately following the burn. Total soil cover estimates made at 147 observation points was 41 percent. Most of that cover is rock, which was estimated at 24 percent cover (*n=117*).

In the fall of 2014 abundant needlecast was observed in moderate SBS units where crown fire did not occur. This was the case in one of five monitoring transects. Needlecast has been demonstrated to reduce erosion rates (Pannkuk and Robichaud, 2003).
Although vegetative soil cover was mostly consumed in the moderate and high SBS areas, newly sprouting shrubs and seedlings were observed in some units and will contribute to soil cover as they grow and new seedlings and sprouts emerge. Observations made in the January of 2015 showed 12 percent of 147 observation points had at least one live plant growing on the soil surface.

Soil erosion is an inevitable consequence of wildfire. Following the fall and winter rains of 2014-15, sheet and rill erosion was observed in units where soil cover was low or non-existent. Erosion, either sheet or rill, was occurring at 31 percent of the monitoring points in the units observed.

Soil Porosity Loss (Compaction): Porosity loss caused by heavy equipment compacting soil as it moves across the land can inhibit root growth and water infiltration. Residual porosity loss from past management is concentrated on main skid trails and landings. Porosity loss was assessed at 147 observation points in January and February 2015. This was possible due to unusually warm weather preventing the ground from freezing. In addition, compaction was assessed in 2011 across Eiler units 514, 5140, 555, 5550, 556, 5560 and 5590 at 30 observation points. Out of a total 177 observation points, four locations indicated a loss of porosity due to mechanical operations. Of those two were considered detrimental.

Litter and duff: Litter and duff are a major nutrient reservoir in conifer forests and provide physical protection to the mineral soil from raindrop impact. They are currently lacking in substantial portions of the project area, particularly in the moderate and high soil burn severity areas. At all of the Eiler monitoring points the forest floor had been consumed. A new forest floor is beginning to form where tree crowns were not completely burned in the fire and needlecast is now occurring. Sixty-six percent of the 147 observation locations had enough needles and other fine woody material on the ground to be a factor in erosion prevention. Where observations separated rock and fine woody material as components of soil cover (*n*=117), an average 40 percent of the total cover was from fine woody material.

Soil organic matter: Soil organic matter (SOM) is the organic matter found concentrated within the upper layer of mineral soil, or topsoil. It is comprised of stable organic molecules at the last stages of decomposition. Soil organic matter is one of the most important constituents in forest soils due to the positive effect it has on soil structure, water holding capacity, infiltration rate, nutrient retention and nutrient cycling. SOM is generally present in sufficient enough amounts within the Eiler Project area to avoid the detrimental physical and biological soil conditions that result when it is removed. This is because only a small portion of the area burned at high SBS.

SOM can be buried when soils are displaced by equipment turning or during earthmoving activities. Small isolated patches of displacement are not considered to be detrimental since the SOM is still onsite. During monitoring of the Eiler project displacement was observed only sporadically except in the north portion of Unit 202, where an area appears to have been ripped, probably as site prep for planting at some time in the past. Tillage operations like ripping are not considered detrimental since the SOM remains onsite and since breaking up compacted layers by tillage is considered a net benefit.

Eiler units 526, 204 and 206 were windrowed in the past and are considered detrimentally deficient in soil organic matter. The windrowing procedure involved scraping off the shrub root crowns with the topsoil using tractor-powered blades and piling the material in long piles commonly referred to as windrows. Today these windrows are up to six feet high, 15 feet wide, and hundreds of feet long. This kind of soil displacement removes soil organic matter to piles on a large scale and is no longer acceptable under present-day Forest Service guidelines and practices.

Large Woody Material (LWM): LWM is greater than 15 inches in diameter, and 10 feet in length. Because down logs were consumed in the fire few logs remain on the Eiler Project landscape. Less than one log per acre was observed during soil monitoring. The number of down logs will increase as trees killed in the fire fall to the ground.

SUMMARY OF EXISTING SOIL CONDITION

Soil cover for erosion prevention is deficient in areas that burned at high and moderate soil burn severity due to consumption of litter and duff, woody material and vegetation. As a result of this loss of soil cover, sheet and rill erosion occurred with the fall and winter rains following the fire. The greatest erosion is occurring where both the forest floor and needles on the trees were consumed, and there is little rock cover. The north face of Cornaz Peak is particularly erosive due to rhyolitic soils on steep slopes with little soil cover. Legacy porosity loss is minimal in the project areas monitored. Litter and duff is deficient in high and moderate burn severity areas as is large woody material. Soil organic matter is considered sufficient in all but the windrowed plantations.

ENVIRONMENTAL EFFECTS

BOUNDING OF EFFECT ANALYSIS

For soil resource assessment, the analysis area is bounded by the project activity units, where ground disturbing activities take place. Soil quality standards are intended to be used at this scale to determine project effects on key soil functions, focusing here upon on-site erosion potential, soil productivity, and hydrologic function.

The analysis is further bounded in time by the foreseeable future period during which effects of this project could persist as detectable, significant effects. Some soil features, such as cover, can recover rather quickly. Others, such as compaction, can persist for decades. In general, effects are discussed as short-term (1 to 5 years) or long-term effects. For cumulative effects, the analysis is bounded in time by past, present, and reasonably foreseeable future projects.

Alternative 1 – Proposed Action

DIRECT EFFECTS OF THE PROPOSED ACTION

Direct effects of the proposed action differ by harvest method and current post-fire site conditions. Expected effects are inferred from field review of current site-specific conditions, knowledge of soil properties, and results of research. Expected effects are assessed with the intent and assumption that integrated design measures and water quality best management practices are effectively applied. The following sections discuss general within-unit effects of the proposed action.

Ground Based Area Salvage Harvesting and Hazard Tree Removal (3741 acres)

These treatments involve mechanical harvest of trees with feller-bunchers, and use of skidders to move trees to landings, followed by a) unit-wide mechanical piling of woody debris in preparation for planting, then pile burning; or b) mastication; or c) broadcast burning. Effects of each procedure are discussed below.

The risk of impacts to soils in tractor salvage units is primarily determined from erosion hazard ratings (EHR) and compaction risk rating (Appendices B and C). Compaction risk is important to consider in this project due to the higher vulnerability of bare soils to runoff from compacted ground.

Erosion risk is highest where bare soil EHR is high and SBS is moderate to high. Compaction hazard is highest where the subsoil has elevated clay percentages. See Appendix D for a list of Eiler Units that have high erosion hazard or high compaction hazard soils. Mitigation of this risk is described below. Project implementers should use this information to aid in scheduling activities when these units will meet the LNF wet weather operations soil moisture guidelines, per IDF.

<u>Effects of mechanical harvesting followed by machine piling</u> (3741 acres)

Soil cover (for erosion prevention): The direct effect of this treatment will be a net increase in soil cover from woody debris from felled trees. Some of that material will be removed during fuels piling, but the residual material would still amount to a net increase in soil cover. Although there will be an overall increase in plant cover due to shrub sprouting and seedling emergence of shrubs, grasses, and forbs prior to project implementation, recent research has shown that plant cover will likely be less where equipment operates relative to unsalvaged ground (Wagenbrenner et al., 2015).

Overall soil cover is expected to increase as a result of tractor salvage. During the felling and moving of tree limbs, bark and needles break off and cover the soil surface. A tractor salvage unit that burned at high vegetation burn severity in the 2012 Chips Fire on the Lassen NF was monitored for soil cover before and after salvage harvest. Results showed a sizable reduction in the amount of bare ground after salvage harvest (Table 1).

Table 1. Soil cover before and after fire salvage harvest. Poker Chip Unit 1005.

	Pre-salvage		Post-salvage
	12/10/2012 n = 30	8/6/2013 n = 70	7/16/14 n = 147
% of points with > 50% bare soil	53	54	29
% of points with green plant	0	50	50

Where machine piling of fuels occurs it will be important to leave adequate material to provide soil cover as stipulated in the IDFs.

Both high and moderate SBS areas will require minimum retention of activity-generated organic materials for erosion control objectives. If post-activity cover is inadequate to prevent erosion in tractor units, the addition of slash or mulch cover may be necessary on a site-specific basis, per IDF.

Porosity: Mechanical treatments in general have the potential to cause detrimental levels of compaction. The compaction hazard rating of these soils is low to high. Little compaction is anticipated except where machine traffic is highly concentrated such as landings and primary skid trails. Soil monitoring in the project area showed little detrimental porosity loss where mechanical harvest had taken place in the last 30 years. IDFs limit tractor operations to periods when the soil is not wet, and there is a provision that will remediate excess compaction if it were to occur. So, porosity loss will be kept within standards.

Litter and Duff: Litter and duff are mostly absent from the moderate and high SBS areas and will be slowly replenished from needlecast where trees survived and from organic inputs from other plants over a longer time period. In the low burn severity areas litter and duff will be lost from skid trails and landings, but would continue to meet the standard of 50 percent areal extent. Where machine piling of fuels occurs some litter and duff will be moved to the burn piles. This will be minimized by piling only as much woody material as necessary to meet fuels objectives, per IDF.

Soil Organic Matter: Soil organic matter will be largely unaffected by displacement associated with tractor yarding because the existing trail system will be used. The risk of a loss of soil organic matter can be high with machine piling because there is a potential to move soil into burn piles. The risk is reduced by piling as little material as necessary to meet site preparation objectives, per IDF. High temperature fire, such as generated in burn piles can cause loss of soil organic matter directly under the piles. These losses would be superficial (top 2 – 3 inches) and limited in extent.

Large woody material: LWM, where it exists, will be left in sufficient amounts to meet Forest standards, per IDF. Within treatment units substantial areas will be left unharvested. These dead trees will provide large woody material on the soil as they gradually fall over.

Mastication (up to 4258 acres)

Mastication is the grinding of small trees and shrubs in place, leaving the wood chips on the ground.

Soil cover (for erosion prevention): Mastication would result in an increase in ground cover material.

Porosity loss: Masticating equipment is low-ground pressure and would not be expected to detrimentally decrease soil porosity when following IDFs.

Soil Organic Matter: Mastication will distribute wood chips and finer materials across the soil surface. Over time a portion of this material would eventually break down into humus and become part of the organic matter within the topsoil.

Litter and duff: Where mastication occurs the overall amount and thickness of litter and duff would increase.

Large Woody Material: Other than occasional disturbance to large down wood, particularly decay class 5 logs, this treatment would have no effect on large down wood.

Broadcast burn (up to 8341 acres)

In the Eiler Project broadcast burning will mainly take the form of “spot burning”, otherwise known as “jackpot burning”, in which greater accumulations of downed woody material are fired and the fire is confined to these spots, due to the scattered and disconnected fuel loading within the broadcast burn unit perimeter. Jackpot burning would be the primary form of broadcast

burning utilized in the project area. This treatment would be applied across the project area, but fire would only be allowed to back into the edge of non-forested areas.

Soil cover (for erosion prevention): Broadcast burning would leave some residual material to protect the mineral soil and maintain high infiltration rates, which minimizes potential erosion (Robichaud, et al, 2005). Jackpot-type broadcast burns are very patchy and will leave a mosaic of organic soil cover. In the Eiler project area rock is a major component of soil cover and will not be affected by the burn.

Porosity loss: Broadcast burning would not impact soil porosity since it does not involve using heavy equipment.

Soil organic matter: Broadcast burning would have no direct effect on soil organic matter. Soil organic matter is located within the mineral soil where soil temperatures would not reach temperatures high enough to burn under controlled conditions.

Litter and duff: With the broadcast burn there will be a net loss in litter and duff, where it occurs. Jackpot-type burning burns a patchwork of disconnected accumulations of downed woody material rather than a continuous underburn, which will limit the extent of litter and duff losses.

Large woody material: Some large woody material would be consumed by the fire, particularly rotted logs. Over time LWM will be replenished as snags fall to the ground.

Windrow spreading (277 acres)

In plantation stands 204, 206 & 526 windrowed soil would be re-spread to restore the soil to a more natural condition. This treatment would be a net gain in soil productivity by replenishing soil organic matter where it is presently deficient. Post-wildfire is the optimal time to spread windrows since there is little risk of damaging trees.

Soil Cover (for erosion prevention): Under present conditions the soil has little cover other than rock due to the fire. That would not change with spreading.

Porosity loss: The equipment spreading the soil would not detrimentally compact the soil because it would be required to follow the soil IDF which limits equipment operation to periods of optimal soil moisture to prevent detrimental porosity loss.

Soil Organic Matter: This treatment would improve the distribution of soil organic matter.

Litter and duff: Litter and duff in the windrowed plantations are mostly non-existent due to the fire. Windrow spreading would not affect litter and duff.

Large Down Wood: This treatment would not impact large down wood since it does not exist in the windrowed plantations where implementation would occur.

Area Salvage, Helicopter Based (722 acres)

Helicopter logging entails very little ground disturbing activity. Because the branches and tops are left on the soil surface where each tree is felled, there is a net increase in soil cover, which will aid erosion prevention until vegetation is reestablished to full cover.

Area Fuels - Mechanical Treatment Only (517 acres)
This treatment includes machine piling of fuels or mastication. Machine piling of fuels is the use of tractors fitted with brush rakes to move surface fuels to piles that will later be burned. Mastication is the grinding of small trees and shrubs in place, leaving the wood chips on the ground. Effects of these treatments were discussed above under "Effects of mechanical harvesting followed by machine piling" and "Mastication".

Area Fuels - Hand Treatment Only (3361 acres)
Hand treatments have minimal impact on soils since no heavy equipment is involved.

Baker Cypress Treatment (361 acres)
Approximately 200 acres of this treatment would be mechanically piled and burned. See effects describing mechanical piling and burning of fuels above.

Reforestation (5645 acres)
Reforestation involves hand work with minimal soil disruption and effects.

Road Construction (2 miles)
One mile of new road and one mile of temporary road would be constructed for the project constituting a long-term loss of approximately 5 acres of productive soils.

SUMMARY OF DIRECT EFFECTS OF THE PROPOSED ACTION.
Ground-based mechanical treatments have the potential to cause detrimental disturbance to soil in the post-fire environment. As discussed, on-site direct effects from the proposed action are expected to be minimal with the project IDFs in place. The potential for activities to generate additional soil cover in the form of woody debris in areas with moderate and high soil burn severity is considered a net benefit for burned areas, but the loss of vegetation resulting from mechanical operations is a detriment.

Ten years of soil monitoring on the forests of the Herger-Feinstein Quincy Library Group (HFQLG) pilot project (which includes the Lassen NF) have demonstrated the effectiveness of Forest Service implementation methods in preventing detrimental soil effects resulting from vegetation management activities in the Northern Sierra Nevada and Southern Cascades. Similarly, Best Management Practices (BMP) monitoring during the same period have demonstrated that the Lassen has been highly effective in its protection of soils and water quality through proper implementation of BMPs. (HFQLG, 2011)

INDIRECT EFFECTS OF THE PROPOSED ACTION
Soil erosion and impaired hydrologic function have a general potential to create indirect effects. Indirect effects of erosion and compaction are off-site effects upon watershed hydrology and/or water quality. Damaged soil hydrologic function, via compaction, can lead to increased runoff, which can affect the quantity, timing, and flashiness of stream flows during precipitation events. As discussed, the direct effects associated with proposed activities are expected to be minimal, so indirect effects would be accordingly quite minimal.

CUMULATIVE EFFECTS OF THE PROPOSED ACTION
The cumulative effects assessment area for the soils resource is bounded in space within the proposed activity area, because this is where the full extent of soil disturbing activities takes place. Effects analysis is bounded in time by past, present, and reasonably foreseeable future actions within that area.

Past, Ongoing, and Reasonably Foreseeable Future Actions (PORFFA).
Past, present and future ground disturbing activities in the Eiler Project area are listed in the Eiler PORFFA (Eiler Project EA Project Record). Ground-based mechanical vegetation management activities have occurred within the Eiler project area over the past decades. Future ground disturbing activities include the activities planned in the Eiler Project proposed action. Although there are other ongoing and planned future activities in the Eiler Project area, none of these projects will take place where ground-disturbing activity in the Eiler Project will occur. So the only reasonably foreseeable future ground-disturbing activities in the Eiler activity units are the Eiler activities themselves.

Cumulative Effects Determination
Based on limited field observations and the PORFFA report past projects have left some degree of persistent porosity loss (compaction). The direct effects of the proposed action are expected to be minimal due to Integrated Design Features that will minimize the detrimental compaction that may be expected in small areas and remediate areas that may exceed the LRMP standard.

In improving soil cover for areas currently lacking it, there will likely be a net benefit in reducing overall erosion potential within the project area, while soil productivity and hydrologic function are maintained.

There are no known ongoing or reasonably foreseeable future actions that involve ground disturbing activity in in the soils analysis area.

The proposed action will not produce any significant amount of adverse direct or indirect soil impacts. Therefore, the proposed action in combination with past, ongoing, and reasonably foreseeable future actions will not produce adverse cumulative effects to the soil resource.

Alternative 2 – No Action

EFFECTS OF THE NO ACTION ALTERNATIVE
Direct effects of the No Action alternative would be of no effect on the soils, as soil disturbing project activities would not take place. Roadside hazard trees could be felled by hand and left in place. Soil cover for erosion protection would gradually increase as low-growing plants establish and spread. Debris from dead trees would fall and provide some soil cover. Present compaction levels and soil hydrologic function would remain unchanged. Organic matter dynamics and nutrient cycling would continue to recover naturally, once vegetation becomes re-established. Some areas will be left lacking surface cover, while other areas will have high concentrations of fuels for the next fire.

Indirect effects of the No Action alternative would be the continued short-term erosion, particularly for areas with moderate and high soil burn severity, until hydrophobicity diminishes and vegetation cover recovers. In the long term, areas with moderate and high soil burn severity would have high fuel loadings into the near future, with a corresponding elevated hazard of detrimental soil effects in the event of wildfire.

Alternative 3: Roadside Hazard Only

This alternative would treat much less land, 1095 acres, with only mechanical harvest and no follow-up fuels treatments or reforestation. The effects on those areas treated would be the same as discussed under Alternative 1, Area Salvage Harvesting and Hazard Tree Removal, except without the mechanical fuels treatment effects. The lands left untreated would recover naturally with the effects discussed above in Alternative 2.

COMPARISON OF ALTERNATIVES

First-year post activity erosion could be slightly elevated in Alternative 1 due to ground disturbance, while erosion in the subsequent two to four years may be slightly higher for Alternatives 2 and 3 without the benefit of enhanced soil cover. However, absolute differences would be negligible given the scale of fire effects.

Table 2. Eiler Comparison of Alternatives

	Alt 1	Alt 2	Alt 3
	Acres		
Ground-based salvage	2567	0	0
Mechanical hazard tree removal	1174	0	1095
Follow up mechanical fuels treatment	3741	0	0
Fuels treatment only	517	0	0
Helicopter salvage	722	0	0
Baker Cypress treatments	361	0	0
Hand hazard tree felling	0	1095	0
Hand fuels treatments	3361	0	1095
Windrow spreading	277	0	0
Reforestation	5645	0	0

Future high-intensity fire hazard due to unburned fuels in the Eiler Fire area represents a threat to soil resources within the project area. The removal of future fuels through harvest and through piling and burning of woody debris will reduce that risk. Alternatives 2 and Alternative 3 would do little to alleviate the hazard.

Only the action alternative would spread windrows, which is a benefit to soils.

The proposed action alternative does not pose a substantial short-term detriment to soils, and does provide some medium to longer-term benefits for soils and other resource management objectives.

SUMMARY EFFECTS DETERMINATION

The Eiler Fire caused large scale soil disturbance and pulse erosion, albeit natural, with consequential impacts to soil productivity and water quality. The project has little potential to create impacts of a degree or extent to consider detrimental or adverse to the soil resource. The main potential soil impact is for erosion exceeding the natural rate. However soil cover in the form of project-generated woody debris and project integrated design features will prevent that from occurring. The proposed action would remove approximately 5 acres of productive soils due to road construction. It would restore soils that were detrimentally impacted by windrowing in the past, a benefit to soil productivity on over 277 acres.

REFERENCES

CSSC, 2001. California Soil Survey Committee. Instructions, Erosion Hazard Rating System for Sheet and Rill Erosion. October 22, 2001.

Day-Bald-Eiler Fire Burned Area Emergency Response. 2014
Soil Resource Assessment. R5 UDSA Forest Service. August 2014.

HFQLG, 2011. Status Report to Congress Fiscal Year 2010

LRMP, 1993. Land and Resource Management Plan. Lassen National Forest.

Page-Dumroese, D.S., Abbott, A.M., Rice, T.M., 2009. Forest Soil Disturbance Monitoring Protocol. General Technical Report WO-82a, USDA Forest Service.

Parsons, Annette, et al. 2010. Field Guide for Mapping Post-Fire Soil Burn Severity October 2010. United States Department of Agriculture, Forest Service. RMRS-GTR-243

Pannkuk, C.D., and Robichaud, P.R, 2003. Effectiveness of needle cast at reducing erosion after forest fires. Water Resources Research, Vol. 39, No. 12.

Roath, Brent, 2006. Detrimental Compaction Risk Rating Guide. Region 5 Version 1.

Robichaud PR, MacDonald LH, Foltz RB, 2005. Fuel management and erosion. In 'Cumulative Watershed Effects of Fuels Management in the Western United States'. (EDs WJ Elliot, LJ Audin). USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-231, Ch. 5.

SNFPA ROD, 2004. Amendment to Sierra Nevada Framework. Record of Decision.

Soil Survey Geographic (SSURGO) Database for Lassen National Forest and Plumas National Forest. Accessed February 2013. Available online at http://soildatamart.nrcs.usda.gov or http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Tippin, L. 2007. Errata Statement Regarding Soil Porosity Forest Plan Standard. Forest Supervisor directive. 11 June, 2007

USDA Forest Service, 2010. FSM 2550 – Soil Management Manual

Wagenbrenner, J.W., MacDonald, L.H., Coats, R.N., Robichaud, P.R., Brown, R.E. 2015. Effects of post-fire salvage logging and a skid trail treatment on ground cover, soils, and sediment production in the interior western United States. Forest Ecology and Management, Vol. 335, pp. 176-193.

Appendix A.

Soils standards and guidelines. Lassen National Forest	
SOILS – Strategy	
LRMP	Forest wide Objectives
Ch. 4, Sec. E, p. 4-27, SO a. (2-5)	2. Field-verify existing reconnaissance soil resource inventory data (Order 3 surveys) for each land-disturbing project.
	3. Conduct detailed soil surveys (usually Order 2) for all project areas that have an erosion hazard rating of "high" or "very high" (according to the R-5 rating system), landslides or unstable areas, potential re-vegetation or regeneration problems, active erosion, or a significant potential to contribute to cumulative degradation of water quality.
	4. Assess each proposed regeneration harvest area to assure the soil is capable of supporting the establishment of trees within five years.
	5. Assess each proposed re-vegetation area to assure the soil is capable of supporting the establishment of grass or brush within two years.
Ch. 4, Sec. E, p. 4-27, SO b. (1)	1. Restore all substantial areas of significantly degraded soil. (1) Identify, evaluate, and establish treatment priority areas of significantly degraded soils. Treat within two decades.
SOILS – Design Criteria	
SNFPA Source	Forest wide Standards and Guidelines
Salvage	
SNFPA ROD Appendix A, Part D, p. 52	Design projects to reduce potential soil erosion and the loss of soil productivity caused by loss of vegetation and ground cover. Examples are activities that would: (1) provide for adequate soil cover in the short term; (2) accelerate the dispersal of coarse woody debris; (3) reduce the potential impacts of the fire on water quality; and (4) carefully plan restoration/salvage activities to minimize additional short-term effects.
LRMP Source	Forest-wide Direction Standards and Guidelines
Ch. 4, Sec. E, p. 4-27, SO a. (1), (a)	a. The areal extent of detrimental soil disturbance (DSD) will not exceed 15 percent of the area dedicated to growing vegetation.
Ch. 4, Sec. E, p. 4-27, SO a. (1), (b)	b. Soil cover is sufficient to prevent the rate of accelerated soil erosion form exceeding the rate of soil formation.
Ch. 4, Sec. E, p. 4-27, SO a. (1), (c) and Errata Statement	c. Soil porosity is at least 90 percent of the measurements found under undisturbed or natural conditions.

(June 11,2007)	
Ch. 4, Sec. E, p. 4-27, SO a. (1), (d)	1. Organic matter is present in amounts sufficient to prevent significant short or long-term nutrient cycle deficits.
	2. Soil organic matter in the upper 12 inches of soil is at least 85 percent of the total soil organic matter found under undisturbed or natural conditions.
	3. Litter and duff occurs on at least 50 percent of the area.
	4. Large woody material, when occurring in the forested area, is at least 5 logs per acre in contact with the soil surface; and represents the total range of decomposition.
Ch. 4, Sec. E, p. 4-29, SO a.	7. Avoid tractor skidding on slopes greater than 35 percent and on soils with an erosion hazard rating greater than 9.
Ch. 4, Management Direction, p. 4-98, Soils	1. Prohibit tractor logging on cinder cone slopes steeper than 20 percent.

Appendix B. Soil Erosion Hazard for Soils in Mechanical Treatment Units

Map Unit	Map Unit Name	Erosion Hazard per Slope Class (%)		
		0-15	16-30	31-45
Intermountain Soil Survey				
110	Boardburn-Hambone complex, 5 to 15 percent slopes	Moderate	Moderate	High
113	Bollibokka loam, 50 to 75 percent slopes	Moderate	High	High
120	Bunselmeier very gravelly sandy loam, 15 to 30 percent slopes	Low	Moderate	Moderate
125	Carberry gravelly fine sandy loam, 2 to 15 percent slopes	Moderate	Moderate	High
126	Carberry gravelly fine sandy loam, 15 to 30 percent slopes	Moderate	Moderate	High
144	Dekkas fine sandy loam, 0 to 5 percent slopes	Low		
170	Gasper-Scarface complex, 15 to 30 percent slopes	Moderate	Moderate	High
171	Gasper-Scarface complex, 30 to 50 percent slopes	Moderate	Moderate	High
182	Hambone-Boardburn complex, 15 to 30 percent slopes	Moderate	Moderate	High
183	Hambone-Boardburn complex, 30 to 50 percent slopes	Moderate	Moderate	High
212	Keddie loam, 0 to 2 percent slopes	Low		
227	Lasvar-Pitvar complex, 0 to 2 percent slopes	Low		
229	Lava flows-Gassaway complex, 2 to 15 percent slopes	Low		
230	Lava flows-Neer complex, 2 to 15 percent slopes	Low		
231	Longbell gravelly coarse sandy loam, 2 to 15 percent slopes	Moderate	Moderate	
247	Matquaw gravelly sandy loam, 0 to 5 percent slopes	Low		
294	Ricketts-Orhood complex, 30 to 50 percent slopes	Low	Moderate	
304	Rubble land-Typic Vitrixerands complex, 30 to 50 percent slopes	Low		
308	Scarface-Gasper complex, 2 to 15 percent slopes	Moderate	Moderate	
323	Twinbuttes very gravelly coarse sandy loam, 30 to 50 percent slopes	Low	Moderate	Moderate
324	Twinbuttes-Lava flows complex, 2 to 15 percent slopes	Low	Moderate	
325	Wengler very gravelly coarse sandy loam, 5 to 15 percent slopes	Low	Moderate	
326	Wengler very gravelly coarse sandy loam, 15 to 30 percent slopes	Low	Moderate	Moderate
327	Wengler very gravelly coarse sandy loam, 30 to 50 percent slopes	Low	Moderate	Moderate
330	Winnibulli loam, 0 to 2 percent slopes	Low		
338	Zeugirdor-Goulder complex, 15 to 30 percent slopes	Low		
339	Zeugirdor-Goulder complex, 30 to 50 percent slopes	Low		

112	Typic Xerorthents-Yallani family association, 0 to 35 percent slopes.	Moderate	Moderate	High
113	Typic Xerorthents-Yallani family association, 35 to 50 percent slopes.	Moderate	Moderate	High
126	Yallani-Portola families association, 0 to 35 percent slopes.	Moderate	Moderate	High
325It	Wengler very gravelly coarse sandy loam, 5 to 15 percent slopes	Low	Moderate	
326It	Wengler very gravelly coarse sandy loam, 15 to 30 percent slopes	Low	Moderate	Moderate
35	Inville family-Sheld family, moderately deep-Rubble Land association, 15 to 50 percent slopes.	Low	Moderate	Moderate
51	Lava Flow.	Low		
62	Neer-Sadie families complex, 0 to 35 percent slopes.	Moderate	Moderate	High
76	Rubble Land-Pass Canyon family-Bobbitt family, moderately deep association, 35 to 70 percent slopes.	Low	Moderate	Moderate

Appendix C. Soil compaction hazard in mechanical treatment units

Map Unit	Soil	Subsoil Texture	% Rock Fragments	Compaction Hazard
Intermountain Soil Survey				
110	Boardburn-Hambone complex, 5 to 15 percent slopes	l	8	Moderate
113	Bollibokka loam, 50 to 75 percent slopes	cl	13	High
120	Bunselmeier very gravelly sandy loam, 15 to 30 percent slopes	v gr cl	42	High
125	Carberry gravelly fine sandy loam, 2 to 15 percent slopes	gr fsl	28	Low
126	Carberry gravelly fine sandy loam, 15 to 30 percent slopes	gr fsl	28	Low
144	Dekkas fine sandy loam, 0 to 5 percent slopes	ls	13	Low
170	Gasper-Scarface complex, 15 to 30 percent slopes	gr sl	20	Low
171	Gasper-Scarface complex, 30 to 50 percent slopes	gr sl	20	Low
182	Hambone-Boardburn complex, 15 to 30 percent slopes	v gr scl	8	High
183	Hambone-Boardburn complex, 30 to 50 percent slopes	v gr scl	8	High
212	Keddie loam, 0 to 2 percent slopes	l	13	Moderate
227	Lasvar-Pitvar complex, 0 to 2 percent slopes	c	0	High
229	Lava flows-Gassaway complex, 2 to 15 percent slopes	gr l	26	Moderate
230	Lava flows-Neer complex, 2 to 15 percent slopes	v cb l	39	Moderate
231	Longbell gravelly coarse sandy loam, 2 to 15 percent slopes	gr l co s	24	Low
247	Matquaw gravelly sandy loam, 0 to 5 percent slopes	v fsl	5	Low
294	Ricketts-Orhood complex, 30 to 50 percent slopes	v co cl	44	High
304	Rubble land-Typic Vitrixerands complex, 30 to 50 percent slopes	v gr sl	49	Low
308	Scarface-Gasper complex, 2 to 15 percent slopes	sl	12	Low
323	Twinbuttes very gravelly coarse sandy loam, 30 to 50 percent slopes	x gr co sl	53	Low
324	Twinbuttes-Lava flows complex, 2 to 15 percent slopes	x gr co sl	43	Low
325	Wengler very gravelly coarse sandy loam, 5 to 15 percent slopes	v gr co sl	40	Low
326	Wengler very gravelly coarse sandy loam, 15 to 30 percent slopes	v gr co sl	40	Low
327	Wengler very gravelly coarse sandy loam, 30 to 50 percent slopes	v gr co sl	40	Low
330	Winnibulli loam, 0 to 2 percent slopes	cl	5	High
338	Zeugirdor-Goulder complex, 15 to 30 percent slopes	cb sl	25	Low
339	Zeugirdor-Goulder complex, 30 to 50 percent slopes	cb sl	25	Low

112	Typic Xerorthents-Yallani family association, 0 to 35 percent slopes.	gr fsl	22	Low
113	Typic Xerorthents-Yallani family association, 35 to 50 percent slopes.	gr fsl	22	Low
126	Yallani-Portola families association, 0 to 35 percent slopes.	gr fsl	15	Low
325It	wengler very gravelly coarse sandy loam, 5 to 15 percent slopes	v gr co sl	40	Low
326It	wengler very gravelly coarse sandy loam, 15 to 30 percent slopes	v gr co sl	40	Low
35	Inville family-Sheld family, moderately deep-Rubble Land association, 15 to 50 percent slopes.	c cb sl	30	Low
51	Lava Flow.	rock	100	Low
62	Neer-Sadie families complex, 0 to 35 percent slopes.	l	10	Moderate
76	Rubble Land-Pass Canyon family-Bobbitt family, moderately deep association, 35 to 70 percent slopes.	scl	5	High

Appendix D. Eiler Units with elevated soil hazards

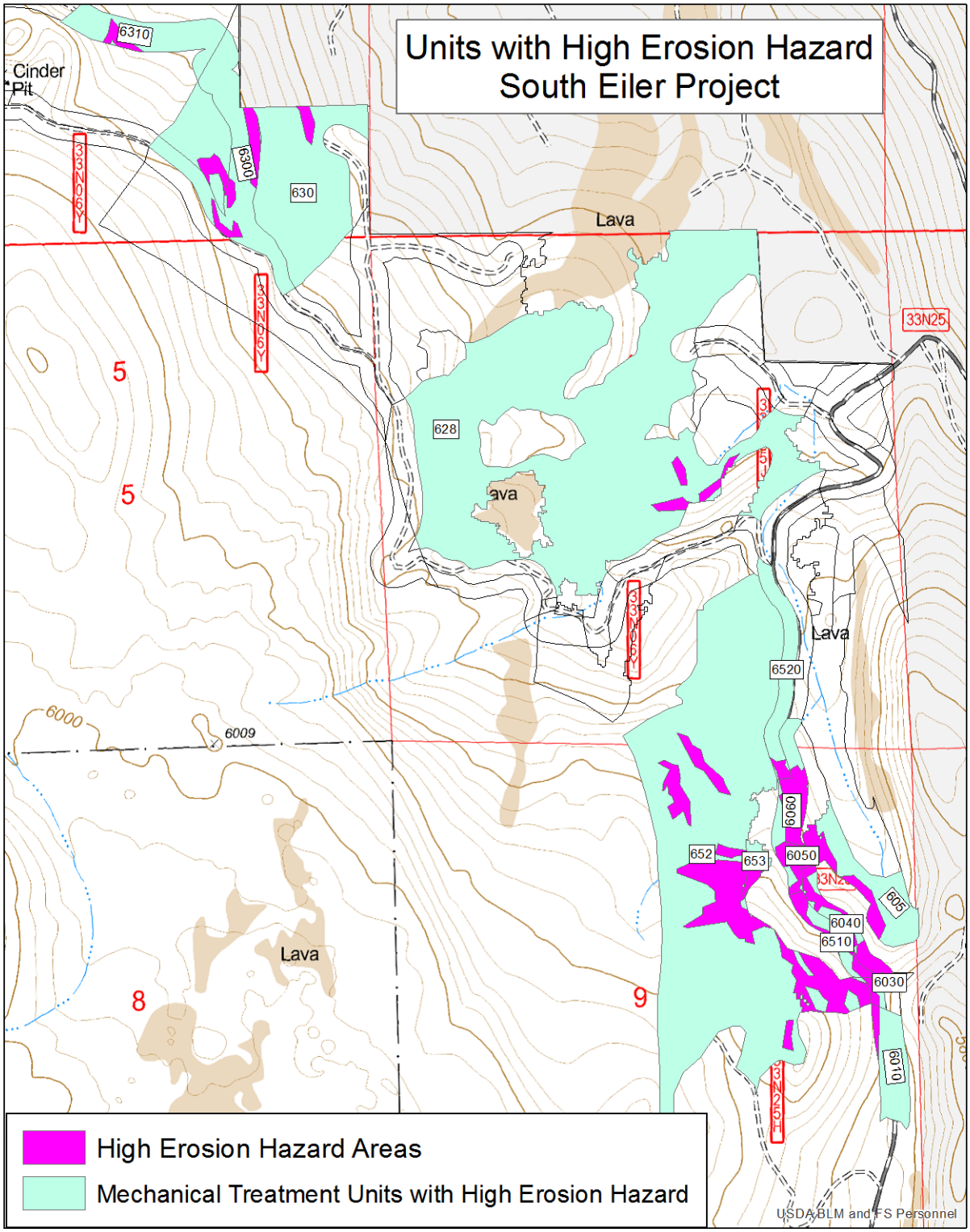
The following Eiler units have portions of **high erosion hazard** soil.
These generally occur on slopes greater than 20%
See Erosion Hazard Maps (Appendix E-1, E-2. & E-3) for locations

201	235	312	628	2350	6010
202	236	313	630	2360	6030
207	240	314	652	2430	6040
211	241	318	653	2500	6050
213	249	319	2010	2530	6060
220	250	320	2070	2550	6300
225	253	323	2100	2560	6310
227	257	354	2240	3180	6510
229	307	357	2250	3230	6520
234	308	605	2260	3300	

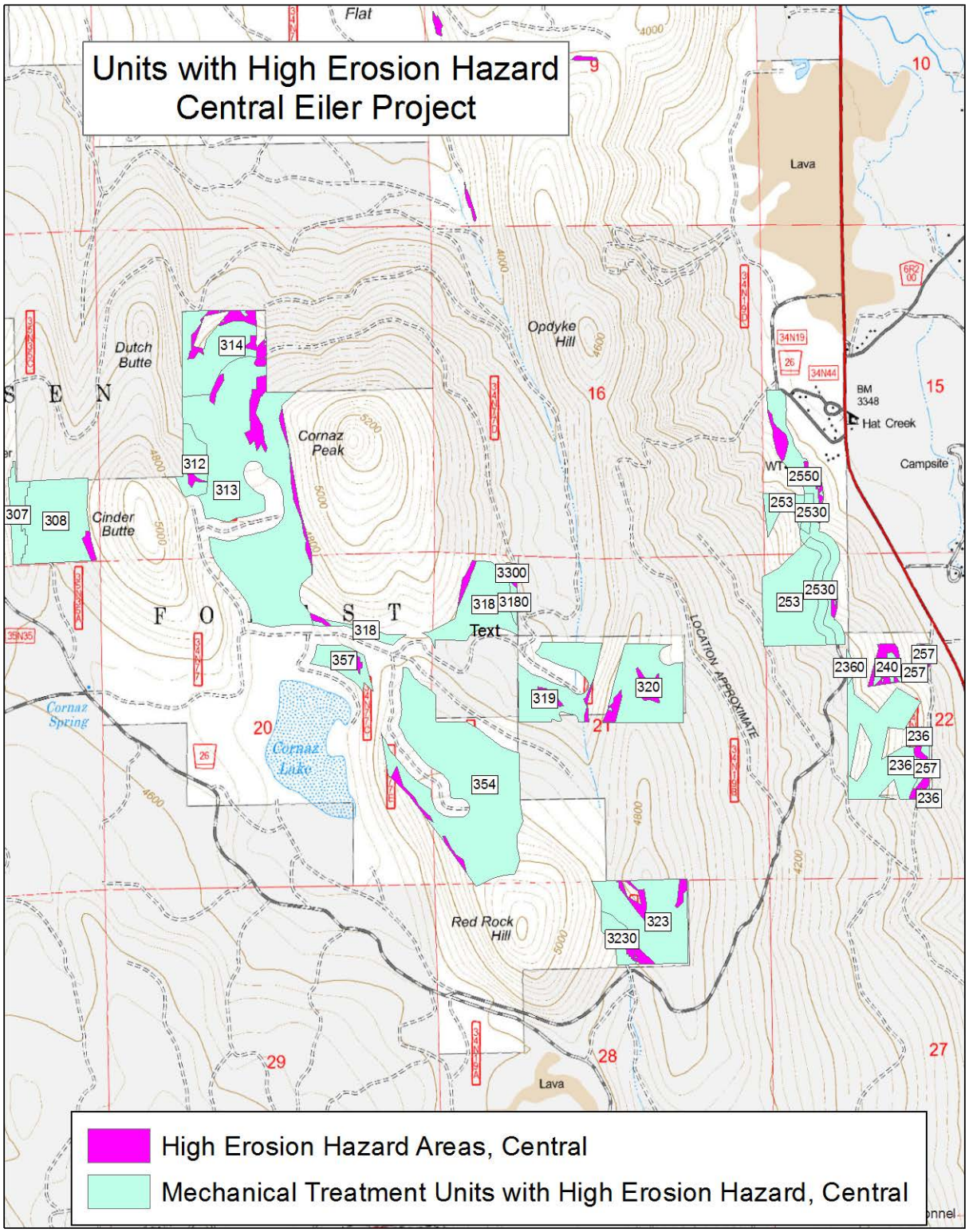
The following Eiler units have portions of **high compaction hazard** soil.
See Compaction Hazard Map (Appendix F-1, F-2, & F-3) for locations

201	240	357	2270	3570
202	241	603	2280	3630
207	249	605	2290	
210	250	2020	2320	
212	253	2040	2330	
213	257	2050	2350	
214	265	2060	2360	
215	303	2070	2500	
216	307	2100	2530	
217	308	2120	2560	
218	312	2130	3030	
220	313	2140	3050	
221	314	2160	3130	
225	318	2170	3180	
227	319	2190	3190	
229	320	2200	3200	
233	321	2210	3210	
234	323	2230	3230	
235	333	2240	3300	
236	354	2250	3540	

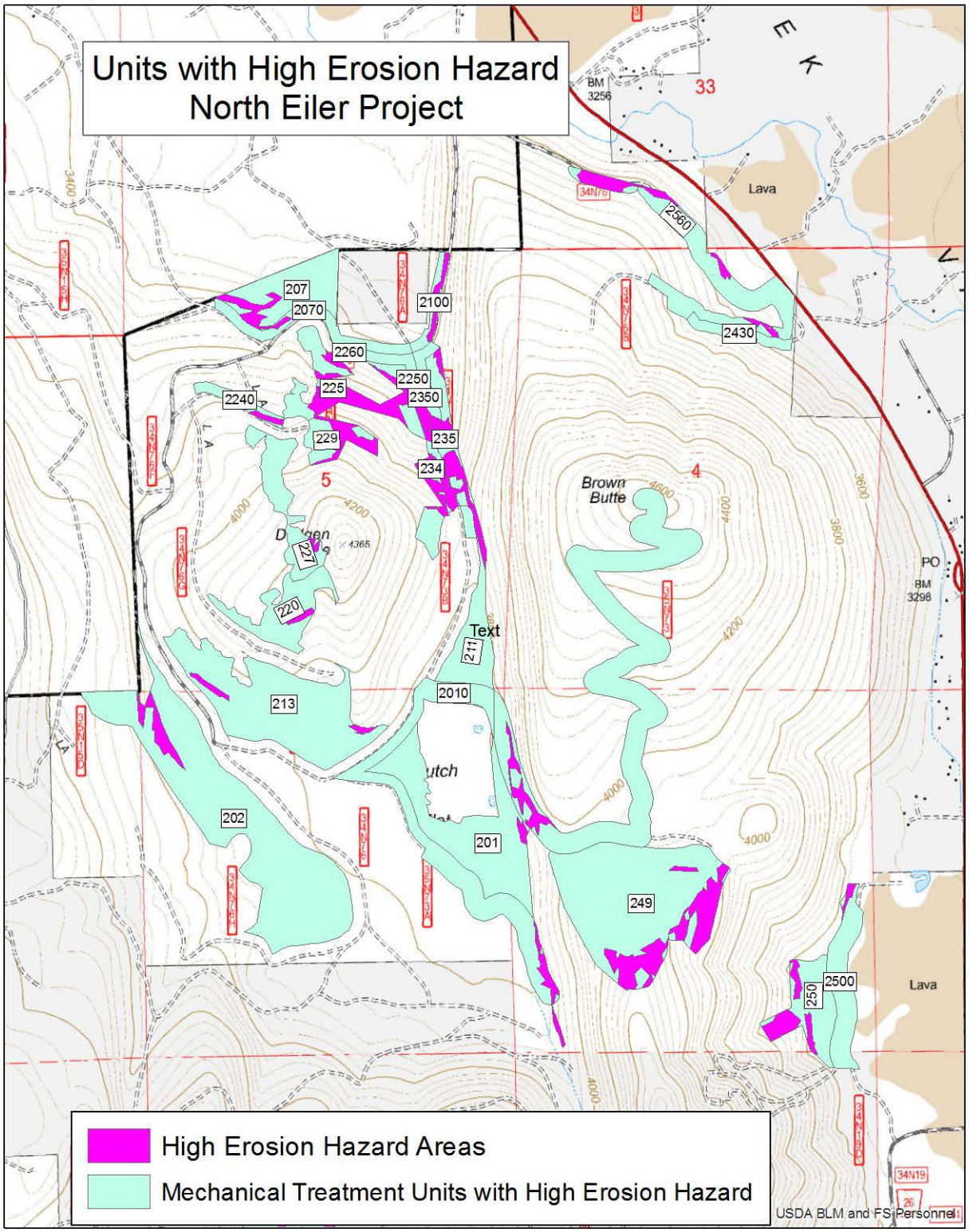
Appendix E-1. South Eiler Project High Erosion Hazard



Appendix E-2. Central Eiler Project High Erosion Hazard Areas



Appendix E-3. North Eiler Project High Erosion Hazard Areas



Appendix F-1. South Eiler Project Areas with High Compaction Hazard Soil

Appendix F-2. Central Eiler Project Areas with High Compaction Hazard Soil

Appendix F-3. Central Eiler Project Areas with High Compaction Hazard Soil.