The Rim Fire Recovery Project

Soil Report

Eric Nicita

Soil Scientist
Eldorado National Forest

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Introduction

This section describes the regulatory framework that applies to management of soil resources on Stanislaus National Forest System lands and analyzes effects to these resources associated with the alternatives proposed by the Rim Fire Recovery Project. Soil quality indicators are analyzed to assess project effects on soil productivity and soil hydrologic functions. Several soil quality measures have been developed to support analysis of these indicators, including effective soil stability and soil cover, porosity (compaction) surface soil organic material (includes displacement), soil organic matter and hydrologic function. The geographic scope of the soil quality analysis is generally limited to the footprint of the proposed vegetative treatment units. Changes to soil productivity are not expected to occur outside of the proposed treatment units except in landings located near proposed treatments. To a limited extent, effects associated with changes to soil hydrologic function could potentially extend outside of the units and is analyzed in the Watershed Report for the project.

Analysis Framework: Statute, Regulatory Environment, Forest Plan and Other Direction

The Rim Fire Recovery Project is designed to fulfill the management direction specified in the 1991 Stanislaus National Forest Land and Resource Management Plan (STF LRMP) (USDA 2010), as amended by Sierra Nevada Forest Plan Amendment (SNFPA) Final Supplemental environmental impact statement (FSEIS) and Record of Decision (ROD) (USDA 2004).

Direction Relevant to the Project as it Affects Soil Resources

National Forest Management Act (NFMA) of 1976 (which amended The Forest and Rangeland Renewable Resources Planning Act of 1974)

As described in Forest Service Manual Chapter 2550 (USDA, 2010), this authority requires the maintenance of productivity and protection of the land and, where appropriate, the improvement of the quality of soil and water resources. NFMA specifies that substantial and permanent impairment of productivity must be avoided.

Stanislaus National Forest Land and Resource Management Plan (LRMP)

Forest Plan standards and guidelines provide the relevant substantive standards to comply with NFMA. The 2010 LRMP (USDA, 2010) establishes standards and guidelines to prevent significant or permanent impairment of soil productivity, including:

- Forest projects and activities shall be conducted to maintain or improve soil productivity (36 CFR 219.27(a)(1), 219.27(a)(2), 219.27(b)(5), 219.27(f)). Forest Soil Quality Standards and Best Management Practices will be implemented.
    - Soil properties or conditions should not be altered to the degree that it would result in a 15 percent or more reduction in inherent productivity potential of the soil.

- Soil Cover: Manage soil cover to avoid a High Erosion Hazard condition, as defined by the R-5 Erosion Hazard Rating (EHR) method (USDA FSH 2509.22, 1990). Soil cover should be in place prior to seasonal precipitation.
- Soil Porosity: Maintain soil porosity above 90 of its natural condition on at least 85% of a treatment unit or activity area (90 percent where aerial logging systems are used). Plantable landings and skid trails will be tilled if compacted. Standard does not apply to system roads, administrative sites, or livestock driveways and bedding grounds.
- Surface Organic Matter: Provide for a mix of duff, small woody debris less than 3 inches in diameter, and large woody debris, mostly decaying and unmerchantable logs (minimum 5 logs per acre), represents a range of decomposition classes as defined in the Soil Management Handbook, FSH 2509.18, Chapter 2. Standard may be waived in fuel break areas where fuel loading would be a safety hazard.
- Soil Organic Matter: Maintain topsoil organic matter to at least 85% of its original total in the top 12 inches. Applies to areas dedicated to growing vegetation. Stockpile topsoil to rehabilitate disturbed areas such as borrow pits, mined areas, material storage sites, etc.
- Best Management Practices (BMPs): Implement BMPs to mitigate environmental impacts of erosion, compaction, and soil displacement. Require special soil mitigation to use ground skidding equipment on slopes steeper than 35%. Require special soil mitigation to use ground skidding equipment on soils that erode, displace, or compact easily. Where actual or potential slope instability is identified, specific mitigating measures will be developed by an interdisciplinary team including a geologist.

- Design and implement management practices that maintain or improve soil hydrologic function and soil environmental health.
  - Soil Hydrologic Function: Infiltration and permeability are not reduced to ratings of 6 of 8 as defined in Region 5 Erosion Hazard Rating System (Chapter 50, R-5 FSH 2509.22).
  - Soil Environmental Health: Soil reaction class, buffering or exchange capacities, or biological populations are not altered to the degree that significantly affect soil productivity, soil hydrological function, or the health of humans and animals. Develop local threshold values and submit to Regional Forester for standardization among forests.

National Forest Service Manual for Soil Management

Forest Service Manual 2550 (USDA, 2010) establishes the management framework for sustaining soil quality and hydrologic function while providing goods and services outlined in Forest land and resource management plans. Primary objectives of this framework are to inform mangers of the effects of land management activities on soil quality and to determine if adjustments to activities and practices are

necessary to sustain and restore soil quality. Soil quality analysis and monitoring processes are to be used to determine if soil quality conditions and objectives have been achieved.

Forest staff is to determine soil quality indicators and measures that are appropriate for the proposed activities. Most soil quality indicators are observations and measurements taken at the soil surface and in the upper mineral soil since this region of the soil profile strongly influences soil hydrology and long term soil productivity. Forest staff is directed to estimate the type, amount, and degree of change to soil indicators that the proposed activity may produce by using appropriate analysis methods, scientific literature, past monitoring results, and knowledge of local site and soil characteristics. In most cases, qualitative estimates of the effects of management activities on soils are considered sufficient to meet analysis objectives.

The major objective of soil quality monitoring is to ensure that ecologically sustainable soil management practices are applied. Soil quality monitoring is to be used to validate and refine management decisions. Monitoring information collected allows land managers to determine if land management plan desired conditions are being achieved. The focus of project level monitoring is observation and documentation of the implementation of soil protection prescriptions.

Region 5 National FSM Supplement for Soil Management

Region 5 FSM 2500 chapter 2550 Supplement (USDA 2012a) establishes soil functions (support for plant growth (productivity) function, soil hydrologic function, and filtering and buffering function) that the region will use to assess soil conditions. The analysis standards are to be used for areas dedicated to growing vegetation. They are not applied to lands with other dedicated uses, such as system roads and trails or developed campgrounds.

Region 5 2011 Amendment to the Forest Service Soil and Water Conservation Handbook

The Pacific Southwest Region (Region 5) of the USDA-Forest Service has recently adopted an amendment to the Forest Service Handbook, Section 2509.22, Chapter 10 (Water Quality Management Handbook) (USDA 2011). This handbook improves and replaces the BMPs presented in Water Quality Management for Forest Service Lands in California. The Forest Service water quality protection program relies on implementation of prescribed BMPs. These best management practices are procedures and techniques that are incorporated in project actions and have been determined by the State of California to be the most effective, practicable means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. Improvements to Forest Service BMPs, as presented in the 2011 Handbook amendment, include more detailed descriptions of individual BMPs (section 12), a requirement that site-specific BMPs be included in timber sale contracts (section 13), and direction that legacy sites (sites disturbed by previous land use that is causing or has potential to cause adverse effects to water quality) within timber project boundaries will be restored or improved.

Additionally, the 2011 Handbook amendment establishes an expanded water quality management monitoring program (section 16). BMPs were developed by watershed specialists and included in detail in the Watershed Report.

National Best Management Practices

In addition to BMPs prescribed in the Region 5 amendment to the Forest Service Handbook, BMPs presented in *National Best Management Practices for Water Quality Management on National Forest System Lands* (USDA 2012b) are also applicable to activities proposed in the Project and are also included in detail in the Watershed Report.

Effects Analysis Methodology

Geographic and Temporal Bounds

The scope of the analysis for direct and indirect effects to the soil resource for all proposed activities is limited to the proposed treatment units and connected actions situated outside of the treatment units that are used to support the harvest and related activities, hazard tree removal and temporary roads. Table 1 lists activities expected to affect the soil resources.

Table 1. Activities expected to affect soil resources with each Alternative

Activity	Alternative 1	Alternative 3	Alternative 4
Tractor Harvesting (acres)	24,127	26,252	24,176
Skyline Harvesting (acres)	1,253	1,096	1,066
Helicopter Harvesting (acres)	2,930	3,035	2,568
Tractor/Skyline (acres)	16	16	16
Roadside Hazard Tree Removal (acres)	16,315	15,253	15,692
Watershed Treatment, mastication (acres)	0	1,215	1,215
Watershed Treatment, mastication pre-activity (acres)	0	93	93
Watershed Treatment, drop and lop (acres)	0	2,228	1,798
Total (acres)	**44,641**	**49,188**	**46,624**
Temporary Roads, new (miles)	3.9	9.5	8.4
Temporary Roads, existing (miles)	9.3	22.7	22.1
Temporary Roads, revert to existing (miles)	8.4	3.3	3.3
Total (miles)	**21.6**	**35.5**	**33.8**

The current soil conditions observed reflect the cumulative effects of past activities, regardless of when they took place, so there is no definite time frame or limit for the analysis. For example, if multiple activities have occurred in a given treatment unit over the past 50 years, it is not necessarily possible to separate the effects of older treatments from more recent ones. As a result, it is not practical to set a time constraint on those effects. The future timeframe for the soils analysis must extend until the resource has recovered from the impact of the proposed activities. The persistence of soil effects into the future can vary widely. For example, soil cover may recover within one to three years following a treatment. Soil compaction effects, however, may last for decades (Poff, 1996).

Assumptions Specific to Soils

- Effective application of Best Management Practices for the action alternatives: In a burned soil environment, the natural filtering ability of the soil is greatly reduced and accelerated hillslope flow and erosion is expected with appropriate application of BMPs included in the project Management Requirements. See the Watershed Report for BMPs, monitoring requirements, and corrective actions.
- Modeling parameters: Because of the size of the fire, it is assumed that the parameter development used in erosion modeling and Erosion Hazard Rating analysis reflects site specific parameters. Based on the resolution of the tools used, this assumption holds for most of the parameters. However, the parameters based on topography add uncertainty to the models used in this analysis. For this reason, the erosion analysis in this report should only be used as a comparative tool rather than an absolute value prediction. Site monitoring during activities by implementation staff will verify EHRs assumptions for specific areas..
    - Several assumptions were necessary for modeling of erosion and EHR analysis and include:
        - All slopes are uniform. Generally, slopes are more complex than any modeling can account for. Linear mid slopes and variable bottom and top slopes based on the gradient of the slopes were generalized based on the slope gradient. Also soil cover values are assumed to be uniform over a modeled hillslope.
        - The timing, intensity, quantity, and distribution of precipitation are significant factors in erosion and sedimentation and can be highly variable based on the type precipitation event, topography and elevation. This analysis assumes a uniform climate over the fire area based on a modeled weather station situated at 4600 feet near the most intensely burned portion of the fire near Corral Creek.
        - The Hazard Tree portion of the project was modeled for each alternative. However, it is difficult to assign parameters to the intensity of this activity since the frequency and distribution of hazard trees is highly variable along roadways. Thus, even though this activity is likely to be less intense than it is in salvage logging units, it is conservatively assumed to be the same for this analysis
        - Cover values: Pre-fire soil cover values were based on field surveys and remotely sensed data analysis and generalized over the fire area. It is not possible to know what the post fire implementation will be. For assigning post-implementation cover values, soil cover was increased in high fire intensity due to the expected activity fuels that will certainly be left behind after treatment. Cover values were decreased in low to moderate fire intensity. Although activity fuels in the moderate and low fire intensity areas will also increase, machine piling and prescribed fire to achieve fuels objectives will likely decrease soil cover compared with pre-salvage values.

- In Alternatives 3 and 4, Management Requirements prescribe a cover value of 50% or greater in the areas identified as sensitive for soils and hydrology during the development of the proposed project; for this project analysis termed Watershed Sensitive Areas (WSA). Therefore the Water Erosion Prediction Program (WEPP) and EHR are modeled with a minimum of 50% cover in those alternatives. However, some of the areas may not have enough standing material to achieve 50%. Also, for fuel objective to be met, ground fuels cannot exceed 20 tons/acre. Depending on the average diameter of the downed material, it may not be possible to achieve 50% soil cover and less than 20 tons/acre. In Alternative 1, increases in soil cover were anticipated to be slight do to activity fuels, however cover is not expected to approach 50% in these areas.

- Approximately 4300 acres of aerial mulch treatments were applied as part of the Burned Area Emergency Response implementation at a rate of up to 1.5 tons/acre and 100% soil cover. Most of these treatment acres were applied to areas designated in Alternatives 3 and 4 as sensitive areas (WSAs) by the soil scientist and hydrologist that will require efforts of 50% cover post implementation of salvage activities to mitigate effects of the harvest in addition to the Rim Fire. During analysis, the conservative assumption was made that no mulch would remain at the time of implementation or after. This likely will not be the case, but there will be decomposition and incorporation depending on soil moisture and intensity of equipment use.
- Soils that burned with high severity experienced enough heat penetration that enough combustion of soil organic matter occurred to be equivalent of soil displacement.
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Data Sources

Soil Data

- Spatial and Tabular Data: Soil spatial data and soil property tables were acquired from the Natural Resources Conservation Services (USDA 2008). This data is the correlated data derived from the Stanislaus National Forest Soil Survey.
- Soil Interpretations: Soil interpretations were provided by the Region 5 Soil Interpretation Guide (USDA 1999)
- Soil Burn Severity (Appendix B): The Soil Burn Severity and information regarding post-fire soil conditions was provided by Rust *et. al.* (2012).

Remotely Sensed Data

- Vegetation Burn Severity Map (Appendix C): produced by the Remote Sensing Application Center based in Salt Lake City, Utah
- LiDAR(Appendix D for example): high resolution digital elevation model acquired and processed by the Forest Service Remote Sensing Lab based in McClellan, California.

- Multi-Spectral Imagery (Appendix D for example): high resolution satellite data acquired and processed by the Forest Service Remote Sensing Lab based in McClellan, California.

Map Base Layers:

All map base layers, 10 meter Digital Elevation Model, and vegetation information was provided by the Stanislaus National Forest GIS staff.

Soil Quality Functions and Indicators

For this soil analysis, Forest Service staff has developed soil quality functions and indicators that are appropriate for the proposed activities site conditions, and soil characteristics of the project area. Soil quality functions analyzed support plant growth function (soil productivity) and soil hydrologic function. Soil filtering and buffering function is the function of immobilizing, degrading, or detoxifying chemical compounds or excess nutrients. Because no activity is proposed that would affect the soil filtering or buffering capacity of the soil, they are not analyzed in detail.

Soil quality indicators have been developed to support analysis of these functions. While qualitative estimates of the effects of management activities on soils are generally considered sufficient to meet project analysis objectives, quantitative field survey results and remotely sensed information were used to describe the existing condition and to support the analysis of effects of management activities.

Soil Productivity

Soil productivity is the inherent capacity of a soil to support appropriate site-specific biological resource management objectives, which includes the growth of specified plants, plant communities, or a sequence of plant communities to support multiple land uses (USDA 2010). The soil stores water, nutrients, and provides favorable habitat for soil organisms which cycle nutrients. Chemical, physical, and biological soil processes sustain plant growth which provides forage, fiber, wildlife habitat, and protective cover for watershed protection (USDA 2012a). Important measures of soil productivity include: soil cover, soil porosity, and surface organic matter.

Soil Productivity Indicator 1: Soil Stability and Effective Soil Cover

An adequate level of soil cover is needed to maintain soil stability and prevent accelerated erosion. Effective soil cover consists of low-growing vegetation (grasses, forbs and prostrate shrubs), plant and tree litter (fine organic matter), surface rock fragments, and may also include applied mulches (straw or chips). Effective soil cover is the most important soil property in maintaining soil stability and reducing erosion. Surface cover mitigates erosion primarily by intercepting and reducing the detachment energy of raindrops, improving soil porosity, preventing soil sealing, and increasing surface roughness (Larsen *et. al.* 2009).

Figure 1. 50% soil cover ponderosa pine (Pannkuk 2003)

Ground cover protects soil from rainsplash erosion, slows surface runoff, and filters runoff. The percent bare soil is an important control on sediment production following timber salvage (Chase 2006). The presence of even a thin litter layer can substantially reduce soil erosion (Peterson 2009). Soil cover is the dominant control on post-fire sediment yields and generally does not begin providing protection to soil stability until a level of 50% is reached (Larsen *et. al.* 2009). Figure 1 illustrates from Pannkuk and Robichaud (2003) the coverage of 50% ponderosa pine needles.

Desired conditions for soils from FSH 2550 are that "an adequate level of soil cover is maintained to prevent accelerated erosion, and erosion prevention measures are effectively implemented following soil disturbing activities. Generally on slopes less than 35%, a minimum of 50% soil cover in a well distributed pattern is needed to maintain soil stability. Greater amounts of soil cover are generally needed for steeper slopes and in riparian zones.

Effective soil cover was estimated in field surveys. The field collected information was used to correlate existing and potential soil cover with high resolution satellite imagery. The Erosion Hazard Rating (EHR) (USDA 1990) system and the Water Erosion Prediction Program (WEPP) (Elliot 2010) were used to identify areas where accelerated erosion is likely to occur and to estimate the effects that management activities would have on erosion.

Metrics for Indicator 1 are erosion rates as modeled by WEPP, erosion hazard as measured by EHR, and Effective Soil Cover. Table 5 summarizes the indicators for the existing condition for each alternative. A soil will be considered stable if EHR ratings are moderate or below, and soil cover values are greater than 50%. Although threshold values for erosion rates are not established in Management Direction, this analysis uses the assumption that a soil is stable if erosion rates do not exceed rates of formation. The T-factor rating is an interpretation of acceptable soil loss (tons/acre/year) which is related to the soil rate of formation. This interpretation is provided by the NRCS. Values for the soils within the fire area range from 1-5 tons/acre/year with 1 ton/acre equivalent to 2 sheets of paper.

Soil Productivity Indicator 2: Surface Organic Matter:

The concept of surface organic matter is related to effective soil cover, but includes the quality of the material. 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. Surface organic matter is characterized by its level of decomposition; **Oi** is fresh material with no decomposition, **Oe** is organic

material with intermediate decomposition, and **Oa** is highly decomposed organic material with the original structure (needles and leaves) no longer discernible. The importance of the surface organic matter is comprehensively reviewed by Neary et al. (2005). Generally surface organic matter is important for moisture retention, nutrient cycling and storage, soil stability, infiltration, thermal cover, soil fauna and flora habitat, and gas exchange. Effective cover analyzed as Indicator 1 can be any material that provides for soil stability and does not factor in the quality of the cover to soil function. For example, although the organic layers are consumed by fire, needle cast additions can improve effective cover while taking years to incorporate into the soil as organic matter

Greater amounts of soil cover are generally needed for steeper slopes and in riparian zones (USDA, 2012a). Field crews collected data on the quantity and quality of soil cover and logs on the ground. Although the quantity and quality of surface organic material is unknown prior to the fire, field observations related to the Vegetation Burn Severity Map (Figure 1.04-2) allows for a good correlation of existing and potential cover as related to the canopy change caused by the fire. To estimate surface organic material, it is assumed that the amount of heat in both the moderate and high soil burn severity areas incinerate enough surface organic material to affect the soil productivity of these areas.

Soil Productivity Indicator 3: Soil Organic Matter.

Soil organic matter, also known as soil humus, is the highly decomposed organic material that is incorporated into the mineral portions of the soil. Soil organic matter is important for holding soil water, cycling nutrients, and reducing soil strength. 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.
Impacts to soil organic matter generally come from both excessive soil heating and soil displacement from mechanical disturbances. Soil heating volatizes both the complex organic compounds and plant nutrients. Changes in the soil organic matter can affect soil nutrient cycling, water holding capacity and aggregate stability.

Metrics for soil organic matter (SOM) is the extent of soil depleted either by volatilization from fire or displaced by project activities. Soil burn severity ratings of high were used to determine where SOM was volatized during the fire. High soil burn severity usually indicates penetration of heat into the soil and the consumption of fine roots and soil organic matter. This indicator was not directly measured by field crews, but was evaluated by the soil assessment team during BAER operations to develop the soil burn severity map. An analysis of existing and potential skid trail locations was used to identify areas where mechanical displacement of the SOM was likely. To survey the amount of existing disturbance within units, hand-digitizing of all disturbances based on LiDAR was completed.

For the purpose of this analysis, detrimental soil displacement is defined as occurring when either 2 inches or ½ the total thickness (whichever is less) of the humus-enriched topsoil (A horizon) is removed from an area of 3 square feet or larger.

Indicators 4: Soil Porosity

Soil porosity is the volume of pores in a soil that can be occupied by air, gas, or water and varies depending on the size and distribution of the particles and their arrangement with respect to each other. The two primary mechanisms for reducing soil porosity are compaction and soil sealing. The use of heavy forestry equipment and frequent stand entries increases bulk density and decreases the porosity of soils, which increases the potential for detrimental compaction (Powers et al 1998). Soil sealing is the process after a fire where fine soil particles fill the soil pores and reduce the flow of water through the voids. The degree and extent of susceptibility to compaction is primarily influenced by soil texture, soil moisture, coarse fragments, depth of surface organic matter, ground pressure weight of the equipment, and whether the load is applied in a static or dynamic fashion. Soil compaction and increased soil strength can cause slowed plant growth, impeded root development, poor water infiltration, restricted percolation, increased overland flow during high precipitation events, and can cause plant nutrients to be relatively immobile or inaccessible (Poff, 1996). Recent research suggests that the effect of severe compaction on biomass productivity is highly dependent upon soil texture (Powers et al 2005). Within the Rim Recovery project area, soil textures of loam and clay loam produce widespread severe compaction ratings (Table 2). The extent of detrimental soil compaction should not be of a size or pattern that will result in a significant change in production potential and should not result in common occurrences of overland flow and erosion within treated units (indicating that the infiltration and permeability capacity of the soil has been exceeded for the local climate).

Soil sealing and water repellency (hydrophobicity) resulting from a fire also affects area soil hydrologic function. As summarized by Larsen et al. 2009, soil seals are a thin layer of dense soil at the mineral soil surface. Metrics for soil porosity is the amount of ground that was impacted by logging equipment and high soil burn severity with the assumption that primary and secondary skid trails will be decompacted with subsoilers or ripping shanks. Compaction was identified by field crews using an evaluation of soil structure, particularly platey structure. Field observations were then used to correlate disturbances identified using the same methodology used to identify displacement. Soil sealing, evaluated using soil burn severity, is likely to occur where ratings are high. The amount of existing disturbance within units is estimated using the LiDAR data set; however, this indicator is discussed qualitatively.

Methodology for Soil Resource Analysis

The following section is a summary of the methods used to document and analyze the affected soil environment and the effects of proposed activities. A detailed description of the analysis methods can be found in Appendix D of this report.

Soil Description and Interpretation

Soils information for this analysis was derived from Stanislaus National Forest Soil Survey and obtained from the Natural Resources Conservation Services (NRCS) Soil Data Viewer (SDV). The SDV provided both spatial and soil property information for both field survey and analysis.

There were 67 soil map units within the fire area. Because of the size of the fire, a soil map was generated and analysis was completed based on dominant soil series and closely related soils series in a map unit. A soil map unit is a collection of areas defined and named the same in terms of their soil components (e.g., series) or miscellaneous areas or both. Soil series are families of soils having similar profiles, and developing from similar original materials under the influence of similar climate and vegetation. The soil map is included in Appendix A and a table of soil percentages and relevant soil properties used in analysis is included in Table 2.

Site Observations

In the fall of 2013, specialists from multiple resource disciplines assessed soil condition measures within the fire boundary. The goals of field observations were to identify soil properties useful in confirming the accuracy of the soil survey and to identify existing soil conditions to help analyze cumulative effects and understand soil response to management. Field observations were also important to correlate the site conditions to remotely sensed data.

Site observation methods were developed for rapid assessment by field crews. Plot selection was stratified based on burn severity, soil type, topography, and visual satellite imagery expression. Site specific information collected by crews or remotely sensed in GIS included topography, soil physical properties, existing disturbance, and existing and potential soil cover. Ninety-seven plots were recorded.

Remotely Sensed Data Analysis

Analysis for this project utilized several remotely sensed sources of information to identify areas of soil and vegetation burn severity, tree mortality, disturbances, and potential and existing covers. Unit-by-unit ocular analysis was completed the remotely sensed data sets.

Erosion Modeling

The Water Erosion Prediction Program (WEPP) Disturbed WEPP batch program (Elliot 2010) was used to model predicted sedimentation resulting from the Rim Fire, salvage activities, and watershed treatments. Disturbed WEPP estimates erosion on an annual basis in contrast to WEPP ERMiT which is a storm driven model that is useful during the Burned Area Emergency Response (BAER) assessment. WEPP is a physically based erosion model which incorporates topography, soils, climate, vegetation and management activity. Because of the size and complexity of the fire, modeled erosion outputs should not be used as absolute values. The purpose of using modeled values is to illustrate relative risk from existing and management activities and to evaluate the relative change in sedimentation associated with proposed activities. Three batch models were created to model post-fire (existing condition), identified watershed sensitive area treatments, and salvage logging effects not within identified watershed sensitive areas.

Soil Erosion Hazard Ratings

The Region 5 Soil Erosion Hazard Rating System (USDA 1990) was used to rate the risk of soil erosion for all soils in the project area post fire, post implementation and incorporating watershed treatments. This system uses various physical soil properties along with climate and site-specific conditions to rate soils for hazard of sheet and rill erosion. For the Erosion Control Plan, Appendix E summarizes those units where EHR exceed a Moderate rating in greater than 15% of the unit.

Watershed Sensitive Areas

Watershed staff examined each unit of the alternatives for areas considered Watershed Sensitive Areas. Watershed Sensitive Areas are portions of the watershed that are at high risk of soil erosion and sedimentation due to the combined effects of the Rim Fire and potential recovery activities. Criteria for evaluating the existence of WSAs include: proposed recovery activities, burn severity including existing and future soil cover, topography including percent slope, slope shape, and slope length, proximity to intermittent and perennial drainages, and proximity to high runoff response soils.

Affected Environment

The Rim Fire started on August 17, 2013 in a remote area of the Stanislaus National Forest near the confluence of the Clavey and Tuolumne Rivers about 20 miles east of Sonora, California. Over the next several weeks it burned 256,283 acres, or about 400 square miles. The burned area within the forest boundary was 176,768 acres, including 22,340 acres of private land, for a total of 69% of the fire area. The remaining 31% occurred to the east in Yosemite National Park. (Fire acreage varies slightly by mapping or reporting sources).

The Rim Fire was the third largest wildfire in California history and the largest wildfire in the recorded history of the Sierra Nevada mountain range. It was also the largest forest fire, burning across a massive conifer dominated landscape. The two fires with more acreage were wind driven brush fires, near San Diego and in the northeast corner of California.

CLIMATE

Climate in the Rim Fire Recovery project area consists of warm, mostly dry summers and cool, wet winters. Precipitation increases in elevation, with a range of about 30 to 50 inches per year across the fire area. Annual variation in precipitation can vary up to about 50 to 150% of average depending on wet or dry years. About 80% of the annual precipitation occurs from November through March. Rain dominates areas below about 4,000 feet though occasional snow occurs in the coldest months. Between 4,000 and 5,000 elevation feet rain and snow is mixed, and above 5,000 feet snow is more common across the landscape. Warm frontal storms can raise snow levels to 7,000 feet or higher. The climate effects on post fire or management erosion is highly variable and dependent on the intensity and duration of the storms. Even though modeling in this analysis assumes a 5 year average precipitation year, the topographic relief

of the Sierra Nevada mountain range can generate extreme localized weather events. A fire the size of the Rim Fire can experience drastically different weather patterns within the fire perimeter during the same precipitation event.

GEOLOGY

The Rim Fire project area includes all three of the principal geologic types in the Sierra Nevada mountain range. Metamorphic rock occupies much of the lower elevations and the Sierra granitic batholith and relic volcanic flows generally occur at higher elevations.

The main geomorphic feature in the project area is the Tuolumne River canyon, which has carved an east-west chasm about 2,500 to 3,000 feet deep through the entire length of the fire area. The adjacent Clavey River has a similarly deep canyon in its lower reaches. The Jawbone Lava Cap lies atop the broad east ridge of the lower Clavey River, a remnant of an ancient lava flow that originated east of the Sierra Nevada mountain range prior to the Sierra uplift about 10 million years ago. North of the Tuolumne canyon the watersheds gradually rise to about 6,000 feet from Duckwall Mountain on the west to Woods Ridge on the east, near Cherry Lake. The landscape climbs to almost 7,000 feet west of Cherry Lake.

Glaciation is another striking geomorphic feature in some eastern locations of the Rim Fire. Glacial periods up to about 90,000 years ago have scoured the upper portions of Tuolumne River canyon as well as Cherry and Eleanor Creeks. Remnant small glaciated alluvial deposits are found in some stream valleys in the fire area down to about 4,500 feet.

FOREST VEGETATION

Vegetation is important for soil development, proper soil function, and soil protection. It shades soil to hold moisture, it is vital to the nutrient cycle, and provides cover that minimizes erosion. Mixed conifer and true fir are the two most common forest types present within the analysis area and because of the rich fire history within the perimeter of the Rim Fire, there are many shrub and hardwood stands intermixed within the forest communities. Within the project area, proposed treatments are primarily located in areas that have been substantially burned in order to recover the value of fire-killed trees. The Rim Fire had a substantial effect on the forested communities. Approximately 75% of the vegetation in areas proposed for treatments are burned with moderate or high vegetation burn intensity. As discussed in the Vegetation report for the project, the ability of forests to regenerate after stand replacing fire is highly dependent on seed sources. Natural seedling regeneration is more likely to occur and dominate in the mixed severity patches of fire and closer to the edge of high severity patches. The percent of grasses, forbs and brush within in the Rim Fire is expected to increase as fire severity increased. Therefore in areas of the fire where shrub development is rapid, it is expected that shade dominate trees and brush will likely be the dominant vegetation types into the future.

Existing Soil Condition

Soils within the project area are primarily derived from metamorphic rock in the lower elevations and the granitic rock at mid and higher elevations. A soil map can be found in Appendix A and Table 2 displays the proportion of general soil groups per alternatives and the corresponding soil properties used in the analysis of this report. Field work during the BAER assessment and for this project verified the existing soil survey information, investigated current soil conditions and effects of the fire, and management capabilities.

The dominant soils within the analysis area are mostly loams, sandy loams, and loamy sands with gravelly to extremely gravelly texture modifiers, indicating high natural infiltration rates, and high rock content in many areas. These soils range from shallow to deep, reflecting a wide range of soil productivity and soil hydrologic groups. Specific dominant soils include the Holland, Josephine, Wintoner, and Fiddletown. Rock outcrop is also common, even dominant, in several map units. Although rock outcrop does not produce sediment, it commonly produces runoff which accelerates erosion on soils downslope; a condition considered in the identification of Watershed Sensitive Areas.

Table 2 Soil families and associated properties used in analysis

Family	Maximum Extent of Activities (Percent of Total Acres)	Soil Properties used in Analysis				
		T-Factor	Surface Texture	Subsurface Texture	Soil Depth, inches	Compaction Hazard
Dystric Lithic Xerochrepts	2.1	1	Cobbly loam	Cobbly loam	20-40	Moderate
Dystric Xerochrepts	0.28	1	Cobbly loam	Coarse sandy loam	20-40	Moderate
Dystric Xerorthents	0.6	1	Coarse sandy loam	Coarse sandy loam	20-40	Slight
Entic Cyrumbrepts	0.06	3	Coarse sandy loam	Coarse sandy lowam	20-60	Moderate
Fiddletown	7.5	2	Gravelly to Bouldery sandy loam	Gravelly sandy loam	20-60	Slight
Gerle	5.4	4	Gravelly sandy loam	Sandy loam	40-60+	Slight
Half Dome	0.17	3	Very Bouldery sandy loam	Cobbly sandy loam	40-60+	Slight
Holland	35.6	4	Loam	Clay loam	40-80+	Severe
Humic Dystroxerepts	0.1					
Josephine	27.8	4	Gravelly loam	Clay loam	20-60+	Severe
Lithic Xerumbrepts	3.7	1	Loamy sand	Sandy loam	0-20	Slight

McCarthy	4.1	3	Gravelly sandy loam	Sandy loam	20-60	Slight
Pinole	0.5	4	Gravelly loam	Clay loam	60-80+	Severe
Rock Outcrop	0.8	1	Unweathered bedrock	NA	0-10	Slight
Typic Dystroxerepts	0.4					
Ultic Haploxeralfs	1.7	1	Sandy loam	Loam		Severe
Wintoner	9.1	4	Gravelly loam	Clay loam	40-60+	Severe
Xerolls	0.1	5	Loam	Loam	40-60+	Severe

The majority of soils (approximately 75%) within the proposed action have a severe compaction rating (high probability to be compacted by activities when moist) and these tend to be the highest productive soils in the project area, particularly the Holland and Josephine soils. Both compaction ratings and productivity are strongly correlated with soil texture. During surveys, field crews noted severe compaction rating on nearly all sampled legacy skid trails sampled confirming the potential of compaction in the project area.

Fire history (Table 3) and past mechanical activities (Watershed report) have had the greatest influence on the existing soil condition. Table 5 summarizes the existing disturbance within the maximum extent of activities.

Fire History Effects on Soil

Although many activities have occurred and affected the area of analysis (See Cumulative Watershed Effects, Watershed Report), the existing soil condition is most dominated by recent fire history. Table 3 summarizes the six largest fires areas affecting the Rim Fire perimeter.

Table 3 Soil Burn Severity for Selected Fires in Relation to the Rim Fire

Fire Name	Fire Year	Fire Size	Soil Burn Severity		
		Acres within Stanislaus National Forest, Rounded	High (%)	Moderate (%)	Low and Unburned Area (%)
Rim	2013	154,530	7	37	56
Stanislaus Complex	1987	147,100	36	20	44
Rogge*	1996	19,400	0	41	59
Granite	1973	17,100	55	30	15
Ackerson**	1996	11,300	19	14	67
Pilot	1999	4,000	46	25	29

*There was no high soil burn severity due to low fuel loading over much of the area because of new tree plantations after the Stanislaus Complex fire. **This fire was much larger overall, with most acreage in Yosemite National Park.

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

Although the Rim Fire was the largest fire in Sierra Nevada recorded history, the soil burn severity was relatively low. The Granite, Ackerson, and Stanislaus Complex fires and post-fire fuel reduction activities removed significant build-up of surface fuels so the heat intensity and residence time was not favorable to high SBS. Table 4 indicates that the SBS as a proportion of the action alternatives is much higher than the fire as a whole simply because very little tree mortality occurred in the unburned and low SBS portion of the fire. There is very little difference in proportion of burn severity between alternatives.

Table 4 Soil Burn Severity by Alternative

Burn Severity	Maximum Extent of Proposed Activities/ acres	Maximum Extent of Proposed Activities, %
Unburned	3409	7.2
Low	15038	31.8
Moderate	23012	48.6
High	5858	12.4

The direct effect fires have on soils is measured by the Soil Burn Severity (SBS). Whereas fire intensity measures the changes to the vegetation community, SBS indicates both changes to the above ground material that provides both existing and future soil cover and the effects to the soil properties caused by heat penetration below ground. SBS categories are summarized as follows (Parsons et al., 2010):

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

A map of SBS for the entire fire area along with the perimeter of past fires is found in Appendix B. For a more detailed narrative of the effects the fire had on the soil, see the Rim Fire BAER Soil Report (Rust et. al. 2013)

The Rim project area has a relatively high level of displacement because soils that burned with high SBS volatize the organic material in the soil that contribute to soil productivity. For the project area, the fire has resulted in the existing condition close to threshold values with the effects concentrated in units where high sbs occurred. Although displacement of soil organic matter is the combined effect of both mechanical disturbance and fire process, fire process is the dominant impact to soil organic matter.

Mechanical Disturbance:

Mechanical equipment used in forest management activities compresses the soil by reducing pore size. This reduction in the pore space and the resulting increase in bulk density reduces the water holding capacity and gas exchange of soils. Compaction also increases the strength of soils which restricts the ability of roots to penetrate the soil matrix. During post-fire field surveys, compaction was found to be the most severe in the Josephine and Holland soils when skid trails and legacy temporary roads were benched and the surface loam soils were displaced exposing the subsoil with greater clay. In most units, there is an extensive skidding network resulting from past timber sales (green and salvage). The extent of this disturbance will be evaluated in LiDAR. During field surveys, plot centers were located at skid trails so the severity of disturbance could be evaluated. Most skid trails sampled revealed high levels of compaction with little recovery. Within these skid trail prisms, soil cover generally is similar to the surrounding areas. Vegetation that grows on these skid trails is either very stunted or non-existent reflecting a reduction of soil porosity and displacement of the soil organic material.

As mentioned above displacement of soil organic matter results from the combined effect of mechanical disturbance and combustion in high sbs areas. Displacement from mechanical disturbance is relatively small compared to the effects of displacement from the Rim Fire. Without fire, the displacement and compaction footprint would essentially coincide.

Summary of Existing Conditions

Table 5 summarizes the existing conditions within the maximum extent of activities, which includes all alternatives. The existing conditions include the effects from past fire and mechanical disturbance.

Table 5 Summary of Existing Condition of Indicators

Indicator			Existing Condition	
			Acres	%
Indicator 1	**Soil Stability, Erosion**	Average Erosion Rate, ton/acre (1)	3.11	----

Indicator 1	**Soil Stability, Erosion Hazard Rating**	Greater than Moderate Rating (acres)	10,725	23
Indicator 1	**Soil Cover**	Area with less than 50% cover (acres)	25,322	53%
Indicator 2	**Surface Organic Material**	Area with less than 50% cover (acres)	28,870	61%
Indicator 3	**Soil Organic Matter**	Area with expected soil productivity loss due to displacement	6062	13%
Indicator 4	**Area with expected soil productivity loss due to compaction or loss of porosity**	Area with expected soil productivity loss due to compaction or loss of porosity	932	2%

(1) Erosion rates for unburned areas tend to be 0.5 tons/acre or less.

Indicator 1: Soil Stability and Effective Soil Cover

In areas of moderate and high burn severity, nearly all of the soil cover and ground vegetation was consumed resulting in a lack of soil stability. Where fire-killed needles were not consumed, heavy needlecast has accumulated since the fire; in most areas, 100% soil cover has been attained. Although not apparent during field visits in the Fall of 2013, rapid resprout of shrubs and herbaceous plant communities is expected in the spring on those soils that burned with a moderate or less SBS which will increase the soil stability.

Soil cover was not found to correlate well with Soil Burn Severity, however, generally soil cover values of 5-20% for High SBS, 5-50% for Moderate SBS and 50 to 100% for Low SBS and unburnt portions of the fire were observed immediately after the fire. Many areas of the fire saw soil heating that consumed most of the ground cover but left much of the canopy killed but the needle structure left intact. When field surveys were conducted in the Fall of 2013, those soils situated under a forest canopy of dead needles were observed to have thick needle cast layers with coverage approaching 100%.

Shrubs such as bear clover, manzanita and whitethorn are likely the first vegetation that will occupy areas of high and moderate SBS and these shrubs typically provide good soil cover in the first 2-3 years after wildfire. During field surveys, the presence of bear clover was noted. Burnt above ground bear clover

was observed throughout the fire area, particularly if the pre-fire canopy was less than 50%. In isolated pockets of the fire, resprouting of the bear clover was evident. Research is not clear on the revegetation of bear clover in relationship to burn severity, but Knapp et al (2012) noted seeds have higher mortality with increasing soil heating. This may delay the recovery of soil stability in the areas with high Soil Burn Severity.

Soil cover was substantially reduced due to the Rim Fire and predicted cover values when implementation would occur would remain low. After winter needle cast, it is expected that 53% of the soils in the analysis area will have less than the 50% soil cover threshold. With a paucity of soil cover, the soils will lack thermal cover and are expected to dry rapidly on the surface with warm weather, particularly on south facing slopes. In a drought year this could lead to significant reduction of soil stabilizing root regrowth. The low soil cover values significantly increases the erosion risk by exposing the soil to splash erosion and reduce the surface roughness.

Erosion Hazard Ratings were evaluated to determine if the level of soil cover was commensurate with a threshold value of Moderate or less. One would expect EHR values to be above threshold values in a majority of the fire area, however, EHR is highly dependent on slope. Low gradient slopes need very little soil cover to maintain a Moderate rating. Only 23% of the maximum extent of area is considered above threshold values of Moderate in the existing condition. As vegetation regrowth and downed woody material accumulates over time, the EHR values are expected to improve.

The Erosion Hazard Rating identifies areas at risk of erosion whereas the Water Erosion Prediction Program identifies the magnitude of erosion. Within the analysis area, the average erosion rate was predicted to be 3.1 tons/acre/year. Although this is below the T-Factor value of 4 tons/acre/year rated for most of the soils in the project area, this is an average. Erosion rates were found to exceed 20 tons/acre/year with areas with an SBS rating of High and on steeper ground.

During project development, key areas were identified by watershed staff where accelerated erosion is not only likely to happen before and after proposed activities, but there is a high probability that soil stability and water quality are at risk from the cumulative impacts of proposed activities. These areas are termed Watershed Sensitive Areas (WSAs) for the purpose of this analysis.

Indicator 2: Surface Organic Matter

Generally speaking, the fire consumed the surface organic material to the same extent as the soil cover. However, the nutrient rich highly decomposed organic material was consumed during the fire in the ‘High’ and ‘Moderate’ SBS. Even though needle cast and crown breakage is expected to accumulate on these areas, they are still considered deficient in Surface Organic Material. Although the thin layer of needlecast is crucial for soil stability, it does not have the nutrient density, soil biology, protection from

soil sealing, water holding capacity, or moderation of infiltration that decomposed soil cover provides to the soil.

The consumption of the duff layers often burns in a mosaic and the extent cannot be predicted although it is likely to be 100% in the 'High' SBS and a majority in the 'Moderate' SBS. At most, 61% of the analysis area is deficient in Surface Organic Material. Levels of Surface Organic Matter should be relatively unchanged in the Low SBS with the lightly decomposed material primarily being consumed. This material is nearly recovered with needlecast. Because the Surface Organic Material generally burns with much less intensity in Low SBS, there is an increase in short term soil nutrients delivered to the soil. It is not known how much the unburned and Low SBS portion of the analysis area was deficient in this indicator prior to the Rim Fire. It is likely that much of these areas were depleted during the 1987 Stanislaus Complex and the 1973 Granite Fire and by the subsequent post-fire logging and reforestation activities.

Indicator 3: Soil Organic Matter

Soil Organic Matter (SOM) is depleted either by mechanical displacement or through thermal volatilization. SOM has been displaced within the fire area but has not yet been determined. In those areas that were mechanically displaced, the SOM was relocated to areas outside of the mechanical disturbance. Although the nutrients in these displaced soils that were not burned at 'High' SBS still remain within the units, the effect is localized and may not have as great of an effect on productivity on the unit as much as that SOM that was lost due to the fire. In the areas of 'High' SBS, carbon and nitrogen were likely volatized. Because Surface Organic Material is not present and vegetation recovery is likely to be delayed, C and N recovery could take several years as the site becomes colonized with shrubs and herbaceous species.

Indicator 4: Soil Porosity

The fire did not reduce porosity through mechanical compaction; however, soil sealing is a significant factor in reduced soil porosity. Soil sealing is the process where fine soil particles and ash fill in the voids that transmit water vertically. Soil sealing generally occurs where the soil structure has been compromised allowing individual particles of soil to be into the voids or where enough ash can fill the soil pores and impede infiltration. Porosity change from the fire generally occurs in the areas of 'High' and 'Moderate' SBS, and can be assumed to coincide with those ratings. Soil sealing is expected to be a relatively short-lived phenomenon and will naturally decrease as vegetation re-sprouts and provides vertical soil pores, ash and the thin soil layer erodes, and as freeze-thaw/biological processes incorporate the components of the ash into the soil structure.

Although the analysis area has a long history of mechanical operations, soil strength level is conducive to favorable rooting environment for desired plant species over the vast majority of the project area. The maximum extent of detrimental compaction indicated by the 2013 surveys and LiDAR analysis has not yet been determined The compacted areas are primarily limited to existing temporary roads, skid trails, and dispersed recreation sites. Designated roads and trails are not considered in the analysis. It is clear that many of these compacted surfaces have impaired site productivity and many of them are the source of accelerated runoff and erosion prior to the fire. These compacted surfaces will be significant sources of accelerated runoff and gully erosion in precipitation events much smaller than what would cause significant hillslope erosion particularly where they are situated below an intensely burned slope. Slopes above Granite Creek, Corral Creek, Skunk Creek, and Reed Creeks are highly susceptible to the effects of the compacted soil surfaces.

Overall, the maximum extent of existing reduced porosity has not yet been determined

Environmental Consequences

Chapters 1 and 2 of the EIS provide detailed information about the design features for the Proposed Action alternative. All mechanical harvest operations would adhere to standards and guidelines set forth in the timber sale administration handbook (Forest Service Handbook [FSH] 2409.15) and the best management practices as delineated in the Region 5 Amendment to the Forest Service Water Quality Management Handbook (USDA 2011a) and the National Best Management Practices for Water Quality Management on National Forest System Lands (USDA 2012). Timber sale contracts contain many standard provisions that help ensure protection of soil and water resources. These include provisions for an erosion control plan, road maintenance, skid trail spacing, and restrictions for wet weather operation.

The environmental consequences section looks at the direct, indirect, and cumulative effects of the Proposed Action (Alternative 1), the No-Action Alternative (Alternative 2), Alternatives 3 and 4 which are alternatives to the Proposed Action.

Direct and Indirect Effects.

The effects to the soil resource by activities for each alternative are compared to the threshold values determined by Management Direction or by thresholds used as proxy. Threshold values are:

- Indicator 1: Soil Stability, Erosion Rates: Erosion Rates that exceed the T-Factor (tons/acre/year). The T-Factor is considered the maximum acceptable soil loss.
- Indicator 1: Soil Stability, Erosion Hazard Rating: EHR values are ‘Moderate’ or less in greater than 15% of a unit area.
- Indicator 1: Soil Cover: Soil cover values are at least 50% over 85% of a unit area.
- Indicator 2: Surface Organic Material: Duff layers are intact over at least 85% of an area.

- Indicator 3: Soil Organic Matter: Where a minimum of 85% of the top 12 inches of soil is maintained over at least 85% of a unit. Soil Burn Severity and mechanical disturbance extent is used as a proxy measure for this indicator.
- Indicator 4: Soil Porosity: Soil porosity will not be reduced by 10% in areas greater than 15% of a unit. Although porosity is not practical to measure, soil strength, root vigor, soil structural change and remotely sensed analysis is used as a proxy to determine the extent of soil porosity change great enough to reduce soil productivity.

The analysis of effects is limited to the proposed activities that are expected to change the values of the indicators as compared to the existing condition. Although many unknowns exist both in existing conditions and the intensity of the activities on a site specific area, conservative estimates were made which would likely overestimate the effects of the activities. By comparing the activity effects to threshold values, this analysis informs the decision maker of the relative risk each alternative has to the threshold values established in management direction. Road construction and rock quarry work would permanently remove those areas from soil productivity. Management direction is to analyze for impacts to soils for areas of soil function. Due to implemention of BMPs those activities are expected to result in effects that are limited in extent to those specific locations and are therefore not expected to significantly impact soil productivity in the project area. Activities analyzed include tractor logging, skyline logging, helicopter logging, road work, prescribed fire, watershed treatments, hazard tree removal along level 2 roads, and Best Management Practices which would be implemented to maintain watershed health.

Cumulative Effects

When analyzing for cumulative effects, this analysis relies on current environmental conditions as a proxy for the impacts of past actions. This is because existing conditions reflect the aggregate impact of all prior human actions and natural events that have affected the environment and might contribute to cumulative effects.

This cumulative effects analysis does not attempt to quantify the effects of past human actions by adding all prior actions. The Council on Environmental Quality issued an interpretive memorandum on Jun 24, 2005, regarding analysis of past actions which states, “agencies can conduct an adequate cumulative effects analysis by focusing on the current aggregate effects of past actions without delving into the historical details of individual past actions.” For these reasons, the analysis of past actions in this section is based on the existing conditions.

This analysis evaluated the effect of future projects for their cumulative effects. The spatial extent of effects on the soil is limited to those areas that have a direct or indirect effect to the soil. The activities expected to cumulatively effect the soils are limited to those activities associated with the Hazard Tree project that is proposed for Level 3-5 roads.

For a complete list of the past, present, and future projects planned for the Rim Fire area, refer to the project record.

Alternative 1 (Proposed Action)

Direct and Indirect Effects

Indicator 1: Soil Stability and Effective Soil Cover

The effects of soil stability and effective soil cover are directly related and analyzed together. Erosional processes, which are the direct measures of soil stability, are primarily changed by management activities when those activities affect soil cover and porosity. While it is not feasible to predict the soil cover following treatments for every location, general assumptions can be made in regards to the departure of soil cover from pre-existing levels based on proposed activities. Activities expected to affect soil stability and cover include harvest activities and fuels treatments.

The existing condition of soil stability and soil cover are above threshold values. The proposed activities of Alternative 1 will do little to change this indicator. There will be slight increases in soil cover due to activity fuels, but not enough of an increase in cover values (less than 50 percent) is expected where the Rim Fire resulted in deficiencies due to high vegetation severity. Erosion rates and Erosion Hazard Ratings will also remain little changed.

Shakesby et al. (1996) found that logging residue can decrease erosion and retain sediment in postfire logged sites. In general, harvest activities are expected to generate ground cover from both slash and breakage. However, there is conflicting research, indicating some areas may not have sufficient soil cover post treatment. Studies directly measuring the change in soil cover following salvage activities are limited; studies of fuel increases however can serve as a reasonable proxy. McIver and Ottmar (2007) found that post-fire logging in an Oregon Ponderosa pine forest increased the amount of material less than 3 inches diameter to 2.8 tons/acre compared to 0.6 tons/acre in burned but unsalvaged stands. Donato et al. (2006) found that fine woody material increased above pre-fire levels following salvage logging of the 2002 Biscuit Fire. Although these studies reported material in weight as opposed to percentage ground cover, they support the idea that logging activities generate fine material that translates into soil cover. However, Chase (2006) found that both tractor logging and cable logging increased the amount of bare soil compared to burned and unlogged control plots. The amount of bare soil decreased with helicopter logging. Chapter 3.05 (Fire and Fuels) also discusses the material expected to be left after salvage operations.

Fuel treatments are also expected to affect the amount of soil cover. Machine-piling with a rake- fitted dozer followed by burning is expected to reduce soil cover to less than 20 tons per acre, creating areas where soil cover may go below threshold values. Machine-piling is not intended to reduce the fine fuels in contact with the ground, but because of “sweeping” of the surface by the larger targeted material, some surface cover will likely be displaced to piles. Monitoring by project administrators is expected to keep

this displacement to a minimum. Pile-burning will have an impact on soil cover at the location of the pile. Fuel staff target 80 percent consumption of material in a pile, which will likely leave less than 50 percent ground cover in that location. Burn piles will be dispersed throughout a unit and typically burn in a mosaic. The area extent of the piles is unknown; however it is expected that pile burning along with other soil disturbing activities will occupy less than 15 percent of a unit to conform to Forest Plan Standard and Guidelines.

A WEPP analysis was used to predict hillslope erosion. Skid trails and cable corridors are compacted surfaces with reduced ground cover that concentrate water and increase rill and gully erosion at water outlets or along the compacted surfaces. Proper installation of BMPs on skid trails will help minimize the increased sediment production due to salvage logging (Chase 2006). Decompacting of primary and secondary skid trails to increase infiltration and surface roughness along with implementation of BMPs is expected to minimize the erosion and sedimentation related to the concentration of hillslope water flow caused by skidding.

Soil cover and erosion were evaluated both at the area extent of the proposed salvage treatments and on a per unit basis. About 59 percent of the proposed action area currently has soil cover of less than 50 percent and 304 units are currently identified as likely to have less than 50 percent cover in more than 15 percent of the area. It is not expected that these values will change significantly as a result of proposed activities. Although effective soil cover is expected to increase in areas of high vegetation burn severity, it is unlikely that activity fuels will add enough soil cover to increase values above the 50 percent threshold in these areas. In the low and moderate vegetation burn severity, harvest and fuels activity are not likely to drop soil cover values below the 50 percent threshold since only activity generated material is treated during timber sale implementation

Table 6 shows modeling of the proposed activities which result in erosion rates dropping slightly for the project area from 3.1 tons per acre to 3.0 tons per acre, while the number of units where erosion rates exceeded acceptable soil loss increased slightly from 178 to 181. This increase is likely due to the decrease in cover values on steep slopes that are proposed for helicopter or skyline logging. EHR rates also will change little as a result of proposed activities. The number of units where the EHR exceeds ‘Moderate’ in over 15 percent of the unit stayed unchanged at 188 units. The small differences in erosion rates and the lack of change in EHR ratings are considered insignificant, but it is likely that erosion will increase as a result of the proposed action.

The use and development of temporary roads is part of the connected action to timber harvest that is expected to affect both soil cover and soil stability. The temporary roads were not considered in the unit-by-unit analysis and are addressed separately. About 4 miles of temporary roads will be constructed and 18 miles of existing temporary roads will be used. Ten of those 18 miles of existing temporary roads will

be obliterated. It is expected that temporary roads will be deficient in ground cover, however, subsoiling, recontouring, installation of waterbars, and application of ground cover will reduce the risk of erosion. In summary, there is much uncertainty regarding the effects proposed activities will have on soil cover and erosion. Research on post-fire logging resulting in erosion is limited (McIver and Starr, 2001) and is not consistent. The lack of change from current conditions based on proposed activities did not show a substantial decrease or increase in EHR or erosion in the models used for this analysis. Although erosion may increase as a result of salvage activities, the magnitude, as Chou (1994) suggests is likely overwhelmed by the erosion and sedimentation resulting from the fire itself. What is clear from both research and modeling is that most of the analysis area will remain below minimum threshold values for effective soil cover and will continue to exceed soil stability thresholds.

Skid trails and cable rows provide a conduit for rill erosion formation thereby increasing the amount of erosion and sediment (Chase 2006). Management requirements are incorporated into the proposed action to mitigate the effects of logging effects on erosion and soil cover. Also, most temporary roads will be obliterated (only those currently operating under other special uses will remain). Madej (2001) found that the activities proposed for restoration of skid trails, landings and temporary roads reduced sediment and runoff significantly when applied to closing forest roads.

Indicator 2: Surface Organic Matter

Proposed activities expected to affect surface organic matter include hauling, temporary road construction and prescribed burning. Harvest activities including the use of tracked feller-buncher type equipment will affect the surface organic matter with localized surface displacement, but will not have a detrimental soil effect on the stands where those activities occur. Long-term surface organic matter is more likely to occur as a result of skidding material to landings and cable yarding material along cable corridors. Removal of the material will be highest closer to landings and on portions of the cable corridors that do not support a fully suspended load. Fresh deposits of broken branches and needle cast will occur, but this accumulation is expected to be thin with surface coverage below threshold standards.

Long-term recovery of the soil organic material in high soil burn severity areas may be affected by the removal of the overstory. With the fine organic material and needles consumed in high severity vegetation burn areas, surface organic matter recovery depends on snag recruitment and needle fall to the soil surface. During field surveys, those portions of the analysis area with the highest depletion of surface organic material correlate with thick stands of burned trees smaller than the 16 inch diameter at breast height that will not be removed. Therefore, material is likely to remain to decompose and rebuild soil organic layers over time.

Piling of fuels is not expected to significantly affect surface soil organic matter; however, piling will reduce the amount of material that could contribute to future surface organic matter. Tractor-piling with a rake is likely to cause limited disturbance and displacement of the organic soil layers as target material

sweeps the soil surface. The burning of piles is expected to generate enough heat to consume all soil organic layers although the extent is expected to be much lower than the threshold of disturbance of 15 percent extent.

Indicator 3: Soil Organic Matter

Displacement is the removal of surface layers of the mineral soil generally by mechanical means. All salvage activities have the potential to substantially displace the SOM. Feller-buncher activity will cause limited displacement. Displacement from harvesters is generally not considered detrimental displacement because the effects are localized. In ground based mechanical harvest units higher levels of displacement are likely to occur with skidding operations. Skidder tracks along with dragging of trees digs into the mineral soil surface and wedges the surface to the side. This creates berms and piles along the edges of skid trails. Skyline units are expected to have displacement along portions of the corridors, with higher displacement levels occurring closer to the landings. The most severe displacement is expected to occur on steeper temporary roads and skid trails. The steeper the slope on both temporary roads and skid trails, the more severe the displacement is likely to be due to cut-banking. Displacement results in the removal of nutrient rich loamy material exposing the high clay content subsurface. This subsurface is deficient in soil nutrients, reduces infiltration, and has higher natural soil strength impeding root penetration. Fox et al. (1989) found displacement caused by windrowing decreased forest productivity dramatically. Displacement can also lead to channelized flow from entrainment between berms, reduced infiltration, reduced surface roughness, and in the case of roads, high levels of compaction. While local displacement damages soil function, the activities resulting in negative effects will not exceed 15 percent of the area and impacts are not expected to be significant.

The other mechanism of displacement involves heat penetration into the mineral soil sufficient enough to char or volatize the organic compounds that form SOM. The diminishment of SOM caused by the Rim Fire dominates the existing condition condition with 72 units exceeding threshold values whereas no units exceed threshold values with mechanical disturbance; however, pile and jackpot burning is expected to produce enough heat where fuel loads exceed 20 tons/acre to consume SOM within the footprint of the piles. The extent and burn severity is unknown and is dependent on the size of the piles and distribution of fuels. The impact will be limited to the pile locations and small areas of high concentrations and therefore is not expected to be significant.

The development of skid trails will have the largest impact on SOM, but management requirements will mitigate the effects; particularly reuse of existing mechanical disturbances where practical. It is clear from LiDAR analysis, there are units with little to no displacement 72 units where the existing condition exceeds the 15 percent threshold for disturbance. Existing skid trails will be reused where practical. For many of the tractor units, existing skid trails are expected to be adequate for salvage harvest and new skid trail development will be unnecessary or minimal. Displacement caused by new skid trails and temporary

road construction will be considered a long-term disturbance as no mitigations to replace displaced SOM are planned.

SOM will recover regardless of management activities in the long-term. SOM is expected to recover more rapidly in areas where SOM was displaced by fire, because nutrient cycling of ash and rapid vegetation regrowth of root dense, nitrogen-fixing shrubs will facilitate deposition of organic matter by decomposing roots and mineralization of decaying material in the soil. On soils where SOM will be impacted by mechanical activities, the recovery is expected to be slower because residual nutrients of the fire will be displaced and SOM replenishing vegetation will be stunted where compaction occurs.

Indicator 4: Soil Porosity

Changes in porosity occur both by the reduction of soil pore space by force applied to the soil surface (compaction) and the filling of pores by soil and ash material (soil sealing). Heavy equipment use is expected to increase compaction within treated areas. For this project, the dominant soil is rated as high compaction hazard primarily because of the increasing clay at depth. Within tractor units, compaction is expected to increase depending on the number of passes and the weight of the machine. Feller-buncher harvesting equipment is considered low ground-pressure equipment and typically does not travel the same location more than twice. Compaction is therefore expected to be slight where mechanical harvesting occurs.

Skidding operations, however, will detrimentally compact the soil. Williamson and Neilson (2000) found that most maximum compaction occurs after 3 passes of log-laden equipment. Landings are areas of high compaction because they support skidding equipment, processors, and log trucks but all landings will be deep tilled after use on this project. Management requirements confine the extent of detrimental disturbance from skid trail patterns to less than 15 percent of a unit. Through LiDAR analysis supported by field verification, it was determined that past activity has resulted in only 3 units exceeding threshold values based on reduced porosity. However, it is likely that more units will exceed 15 percent disturbance because the lack of ground cover will make the soil more susceptible to compaction. Management requirements, such as subsoiling, substantially decrease the negative effects of compaction. Powers (2002) observed that subsoiling significantly improved the porosity of soils. Subsoiling temporary roads, landings and skid trails will limit the extent and duration of effects in these areas. Detrimental disturbance is expected to be minimal in helicopter units. The risk of compaction will be increased in those sky line and helicopter units where feller-buncher type harvesters assist handfallers in removing trees. In these units where no skid trails will be used, detrimental compaction is not expected outside cable corridors.

Although the effects of soil sealing resulting from the fire may be reduced before implementation starts, it is likely that soil surface disturbance through mechanical harvest activities will further reduce the effects of soil sealing by exposing more developed soil structure. Compacted road surfaces reduce infiltration to near zero. Forest roads are the largest source of erosion. This is exacerbated in a burned environment

because the capacity of the landscape to moderate flow and trap sediment is greatly reduced (Peterson et al. 2009). The extent of new and temporary road construction is limited, and while compaction of these surfaces is severe, the limited extent of activities is not expected to result in significant impacts to forest productivity.

Cumulative Effects

The Rim Fire resulted in significant impacts to soils within the analysis area including increases in erosion potential, loss of soil cover, loss of soil organic matter and reduction in soil porosity from soil sealing. With no other actions planned (Appendix B) within the Rim Recovery soil analysis area, the cumulative effects for Alternative 1 are the same as the direct and indirect effects of Alternative 1. The cumulative effect of Alternative 1 is expected to slightly improve soil cover from activity fuels and will increase the porosity in existing skid trails, landings, and abandoned roads identified for use as temporary roads in the project; however in general the activities are not expected to substantially improve the soil indicators within the analysis area.

Alternative 2 (No Action)

Direct and Indirect Effects

Indicator 1: Soil Stability and Effective Soil Cover

Under Alternative 2, only indirect effects to soils occur. Soil cover for erosion protection will be limited to natural rates of accumulation. In areas of lower burn severity, needlecast from dead tree canopies will continue to accumulate as ground cover at natural rates. Soil stability will remain reduced and erosion risk will remain elevated in the short term, for 1 to 3 years, until ground cover and vegetation are reestablished. Higher burn severity areas currently lacking effective soil cover will recover more slowly because woody material will be deposited naturally at a slower rate. Where the potential for soil cover to be added through needlecast is low, soil cover in the short term will mainly be added as dead trees shed branches and fall. Effective soil cover will only be fully reestablished after surface vegetation recovers. This will expose the soil to higher erosion potential over the next 3 to 5 years. Under this alternative, WSAs will not receive additional ground cover as proposed in Alternatives 3 and 4 and therefore the analysis area will not realize a reduction in erosion and sediment in areas identified as higher risk for sedimentation and erosion. Areas will have continued accelerated erosion for 3 to 5 years until soils stabilize and vegetation cover returns.

Indicator 2: Surface Organic Matter

The Fuels Report (project record) states that smaller diameter class snags will fall within the fire perimeter at the highest rate in the first ten years. Larger snags will persist for relatively longer time periods, but most snags will be expected to fall within 20 years post-fire (Hood, Chuck and Smith 2007). Within 10 years, surface fuels are projected to be 78 tons per acre. Within 30 years, surface fuels are projected to average 98 tons per acre due to dead trees falling over (Fuels Report). Richie (2013) showed that 10 years after the Black Mountain Fire, 80 percent of the basal area was on the ground. These

predicted fuel loading levels pose a risk to soil productivity if reburned in a subsequent wildfire. The fuel loadings predicted exceed the levels that cause severe soil heating in a fire (Brown et al. 2003). While it is not possible to accurately predict when a fire will reburn, predicted fuel loadings in Alternative 2 will create an elevated fire hazard leading to excessive soil heating damage. One study, in adjacent Yosemite National Park, examined the effects of multiple fires on vegetation in unlogged areas. Areas of high severity were more likely to burn with an increased area of high severity again in future fires, partly because of a post-fire vegetation shift from forest to brush or chaparral (Wagtendonk 2012). Areas that burned at low or moderate burn severity initially and maintained forest conditions were more likely to burn at low or moderate burn severity in later fires.

Other studies show that if salvaged logged areas reburn, they may have higher overall vegetation burn severity and fire effects than areas that were unlogged (Fraver et al. 2011; Thompson 2007). Most studies on this topic analyze the vegetation effects of reburn. There are fewer studies that directly compare soil effects and associated fire risk or hazard in unlogged and salvage logged areas, therefore impacts to soils in this scenario are less clear. It is expected that fuel loading in contact with the soil surface is likely to be the most important variable in determining risk of fire damage to the soil during a reburn and this Alternative will provide far more down woody material than treated stands.

Indicator 3: Soil Organic Matter

Without the proposed management requirements associated with soil ground cover in WSAs and other areas with elevated erosion rates, soil organic matter could be lost through surface erosion until soils stabilize. In lower burn severity areas, less soil organic matter will be lost due to erosion without alteration by active management, and in the long-term it will develop at natural rates. With increased fuel loadings described under indicator 2, it is possible that soil heating effects could increase in future fires. High surface temperatures, especially from burning downed logs, raise soil temperatures, resulting in increased volatilization of soil organic matter. Prolonged heating under burning logs will lead to lethal temperatures of greater than 122 degrees Fahrenheit for fungi and 212 degrees Fahrenheit (Boyer and Dell, 1980) for nitrifying bacteria at greater soil depths. The loss of SOM is probably the most serious concern in terms of long-term soil effects. SOM dynamics and nutrient cycling will continue to recover naturally, once vegetation becomes re-established.

Indicator 4: Soil Porosity

Existing levels of compaction will not be improved or changed. Existing compaction on abandoned roads and skid trails will remain until natural processes restore soil porosity. Additional compaction will not occur; however, areas with compacted, benched-in skid trails will not be subsoiled and are likely to remain compacted for decades.

Cumulative Effects

With no other actions planned (Appendix B) within the Rim Recovery soil analysis area, the cumulative effects for Alternative 2 are the same as the indirect effects of Alternative 2. The cumulative effect of Alternative 2 is not expected to improve soil cover or soil porosity.

Alternative 3

While Alternative 3 includes less commercial salvage acres, the area of impact is increased through proposed biomass removal. Impacts of biomass removal will result in similar soil effects, as machinery used to accomplish the activities are the same. The proposed temporary road use increases by 14 miles with an increase of approximately 6 miles of new temporary roads. New road construction, however, drops from 5.4 miles to 1 mile. The most substantial change, affecting the soil resource, is that Alternative 3 provides additional soil cover on 3,536 acres using watershed treatments if post-activity soil cover is not greater than 50 percent in WSAs.

Direct and Indirect Effects

Indicator 1: Soil Stability and Effective Soil Cover

The effects of activities to soil stability and effective soil cover from salvage activities and road work activities would be similar to Alternative 1. The addition of soil cover in the WSAs improves the soil stability and the amount of effective soil cover substantially due to the targeted application of soil cover in areas identified as most erodible and lacking in soil cover. Table 6 displays the modeled erosion rate decreases from the existing 3.1 tons per acre per year down to 2.2 tons per acre per year for Alternative 3. The number of units where the average unit erosion rates exceeded T-Factor similarly will decrease when compared to the existing condition from 194 to 136 units.

Improvement in effective soil cover is also expected to increase, but will not be as considerable as the erosion rate reduction. This is due to cover being added only in the highest potential erosion rate areas. Areas deficient in soil cover on gentle slopes are expected to remain deficient in soil cover until it recovers naturally over time. The area of Alternative 3 that is expected to have less than 50 percent soil cover will decrease as a result of proposed activities from nearly 60 percent to 53 percent. The number of units where the amount of soil cover is less than 50 percent in at least 15 percent of the unit is expected to decrease from 335 to 329 units.

The amount of area and number of units that are a ‘Moderate’ EHR rating or less improved with the modeled additions of soil cover, but not as dramatically as improvements in modeled erosion rates using WEPP. The area of EHR ratings above ‘Moderate’ decreased by 1 percent from 22 percent to 21 percent and the number of units that have more than 15 percent of the unit area with a rating of ‘High’ or ‘Very High’ decreased from 209 units to 203 units. Where EHR rating is improved from ‘Very High’ to ‘High’ it is still considered above thresholds set by management direction. Although assumptions are factored into all modeling, the improvement of erosion rates, EHR, and soil cover is substantial enough to conclude the

proposed activities in Alternative 3 will decrease erosion and increase cover sufficiently that they will have a net benefit to the analysis area.

Indicator 2: Surface Organic Matter

The effects to surface fine organic matter will be the same as Alternative 1. The material added to the surface as a result of WSA treatments will not add to the surface organic matter. This material is undecomposed coarser material derived from non-commercial stems and will only cover 50 percent of the soil. Treatments will not add appreciably to soil productivity.

Indicator 3: Soil Organic Matter

Same as Alternative 1.

Indicator 4: Soil Porosity

The effects to soil porosity will be similar to what is described for Alternative 1. The additional treatment will increase the amount of compaction within the analysis area. Additional areas of soil disturbance will not be expected to increase the percent of compaction in any treated areas above the amount expected with Alternative 1. Soil disturbance within Alternative 3 will be reduced in areas where treatment proposed in Alternative 1 does not occur. However, existing compaction on skid trails and landings within untreated areas will also persist.

Cumulative Effects

Same as Alternative 1, except the addition of organic cover for watershed treatments would improve soil cover and reduce erosion rates as described in the direct and indirect effects of Alternative 3.

Alternative 4

Direct and Indirect Effects

Indicator 1: Soil Stability and Effective Soil Cover

Table 6 shows the modeled erosion rate for Alternative 4 is similar to Alternative 3 with a decrease from 3.0 tons per acre per year down to 2.2 tons per acre per year. On a unit-by-unit basis, the number of units where the average unit erosion rates exceeded T-Factor similarly decreased over the existing condition from 186 units to 131 units. The area of Alternative 4 that has less than 50 percent soil cover decreases from nearly 59 percent to 52 percent. The number of units where the amount of soil cover is less than 50 percent in at least 15 percent of the unit decreases from 317 to 311 units. The amount of area and number of units at a ‘Moderate’ EHR rating or less increased, but improvements from added soil cover for EHR were not as dramatic as for modeled erosion rates with WEPP. The area of EHR ratings above ‘Moderate’ decreased by 2 percent from 22 percent to 20 percent and the number of units that are expected to have more than 15 percent of the unit area with a rating of ‘High’ or ‘Very High’ improved from 197 units to 191 units which is the same change in the number of units as Alternative 3.

Indicator 2: Surface Organic Matter

Same as Alternative 3.

Indicator 3: Soil Organic Matter

Same as Alternative 3.

Indicator 4: Soil Porosity

The effects to soil porosity will be similar to that described for Alternative 3. Soil disturbance within Alternative 4 will be reduced in areas where treatment is proposed in Alternative 3 does not occur. However, existing compaction on skid trails and landings within untreated areas will persist.

Cumulative Effects

Same as Alternative 1, except the addition of organic cover for watershed treatments would improve soil cover and reduce erosion rates as described in the direct and indirect effects of Alternative 4.

Summary of Effects Analysis across All Alternatives

Table 6 provides a summary of the effects across all alternatives for Indicators 1 and 2. Indicators 3 and 4 are dependent on analysis of LiDAR by the Remote Sensing Lab and not yet complete. For Indicators 3 and 4, the effects of each alternative are compared qualitatively. Indicators for erosion, soil cover, fine organic material, and soil organic material exceed threshold values used in the analysis.

Indicator 1: Soil Stability and Effective Soil Cover

Alternatives 1 and 2 are similar in the effects to soil stability. High erosion rates and low cover values will remain for both alternatives; however, slight improvements to average erosion rates occur in Alternative 1 due to the addition of activity fuels. Conversely, the number of units where the erosion rates exceed acceptable soil loss increases in Alternative 1 due to the decrease in soil cover in areas that have near 100 percent soil cover in the existing condition. Because of the addition of 50 percent cover prescribed in the WSA units, Alternatives 3 and 4 show marked improvement in cover values, EHR and erosion rates. The treatments are prescribed in those areas where deficiencies in soil stability pose the greatest risk to watershed resources.

Indicator 2: Surface Organic Matter

Little change is expected in Surface Organic Matter between the four alternatives.

Indicator 3: Soil Organic Matter

Little change is expected in Soil Organic Matter between the four alternatives.

Indicator 4: Soil Porosity

The overall porosity for Alternatives 1, 3, and 4 is expected to improve due to implementing the management requirement to subsoil primary skid trails and temporary road prisms situated on existing disturbance. The soil supporting most of the existing skid trails within the proposed units have reduced porosity exceeding threshold values. Porosity decreases in areas off of skid trails may also occur, but the

effect is expected to be limited. Also, mechanical treatment in the action alternatives may increase the porosity by decreasing the effects of soil sealing. Porosity does not change under Alternative 2.

Table 6 Summary of Indicators by Alternative

Indicators			Alternative 1 (357 units + HT)		Alternative 2 (No Action)		Alternative 3 (368 units + HT)		Alternative 4 (350units + HT)	
#	Indicator	Metric	Existing	Post	Existing	Post	Existing	Post	Existing	Post
1	Soil Stability, Erosion	Average Erosion Rate (tons/acre)	3.1	3.0	3.1	3.1	3.1	2.2	3.0	2.2
		Number of units exceeding acceptable soil loss	178	181			194	136	186	131
1	Soil Stability, Erosion Hazard Rating	Number of units with EHR greater than Moderate rating in greater than 50 percent of unit	188	188			209	203	197	191
		Percent area greater than Moderate Rating	23	23	23	23	22	20	22	20
1	Soil Cover	Number of units with more than 50 percent of unit having less than 50 percent soil cover	304	304			335	329	317	311
		Percent area with less than 50 percent cover	58.9	58.9	60.0	60.0	59.5	52.8	58.7	51.5
2	Surface Organic Material	Percent area with less than 50 percent cover of surface organic material	61	61	61	61	61	61	61	61
3	Soil Organic Matter[1]	Number of units with more than 15% of the area with below threshold disturbance	72	-			97	-	90	-
4	Soil Porosity[1]		3	-			4	-	4	-

HT=Hazard Tree Removal (Roadsides)

1. The post activity values for indicators 3 and 4 are unknown due to the uncertainty of the extent existing disturbance will be used.

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Appendices

A. Generalized Soil Map

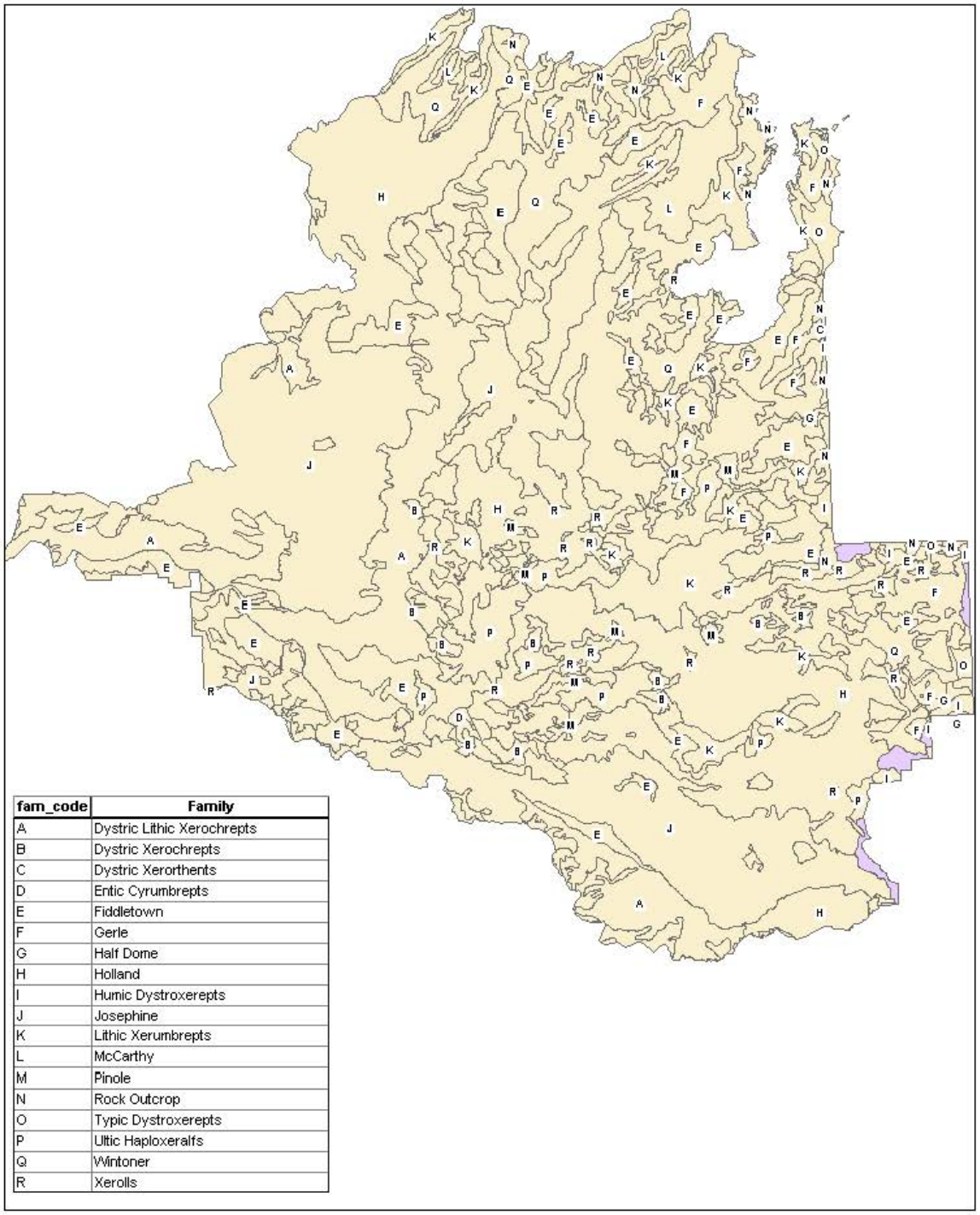
B. Soil Burn Severity Map of the Rim Fire Area

C. Vegetation Severity Map of the Rim Fire Area.

D. Methodology

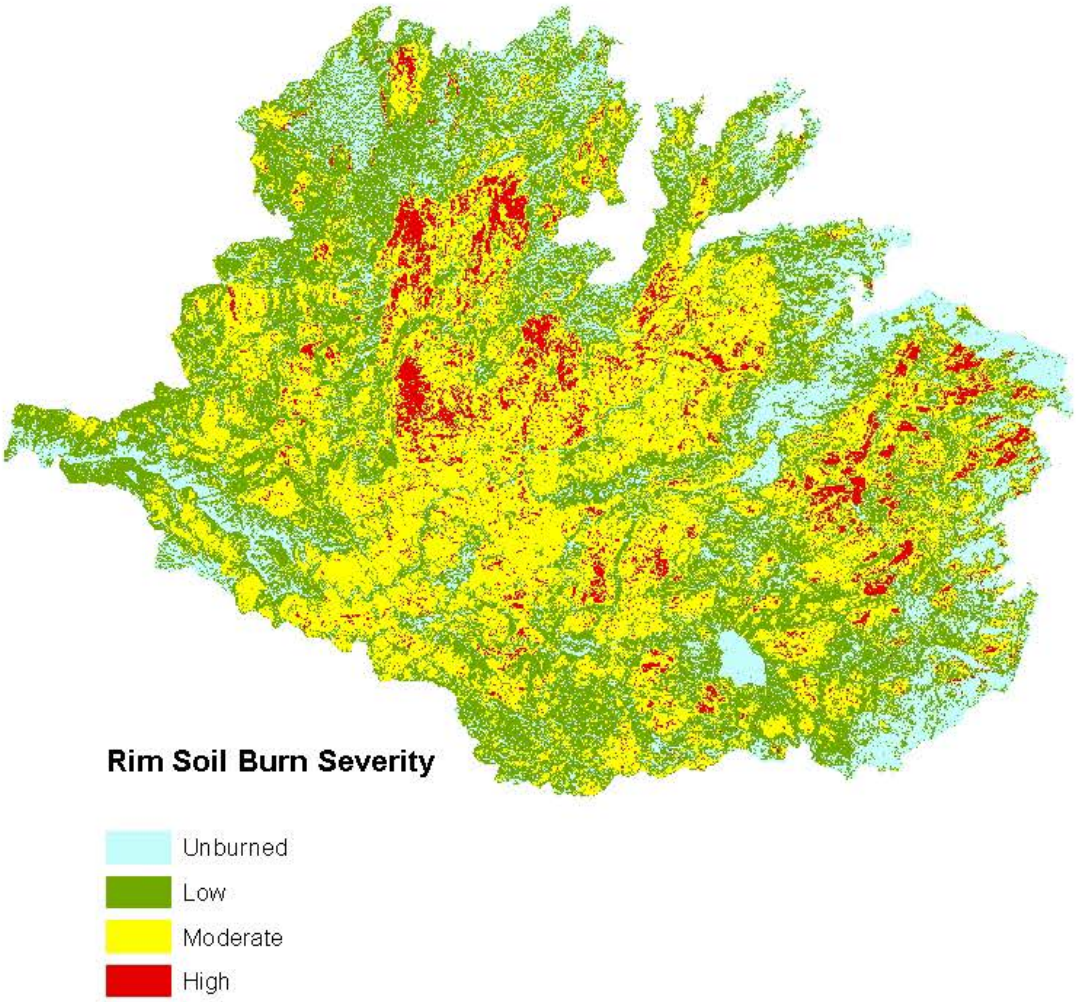
E. Erosion Hazard Rating: Units that exceed Moderate rating in greater than 15% of any unit.

APPENDIX A: Generalized Soil Map of the Stanislaus Portion of the Rim Fire.

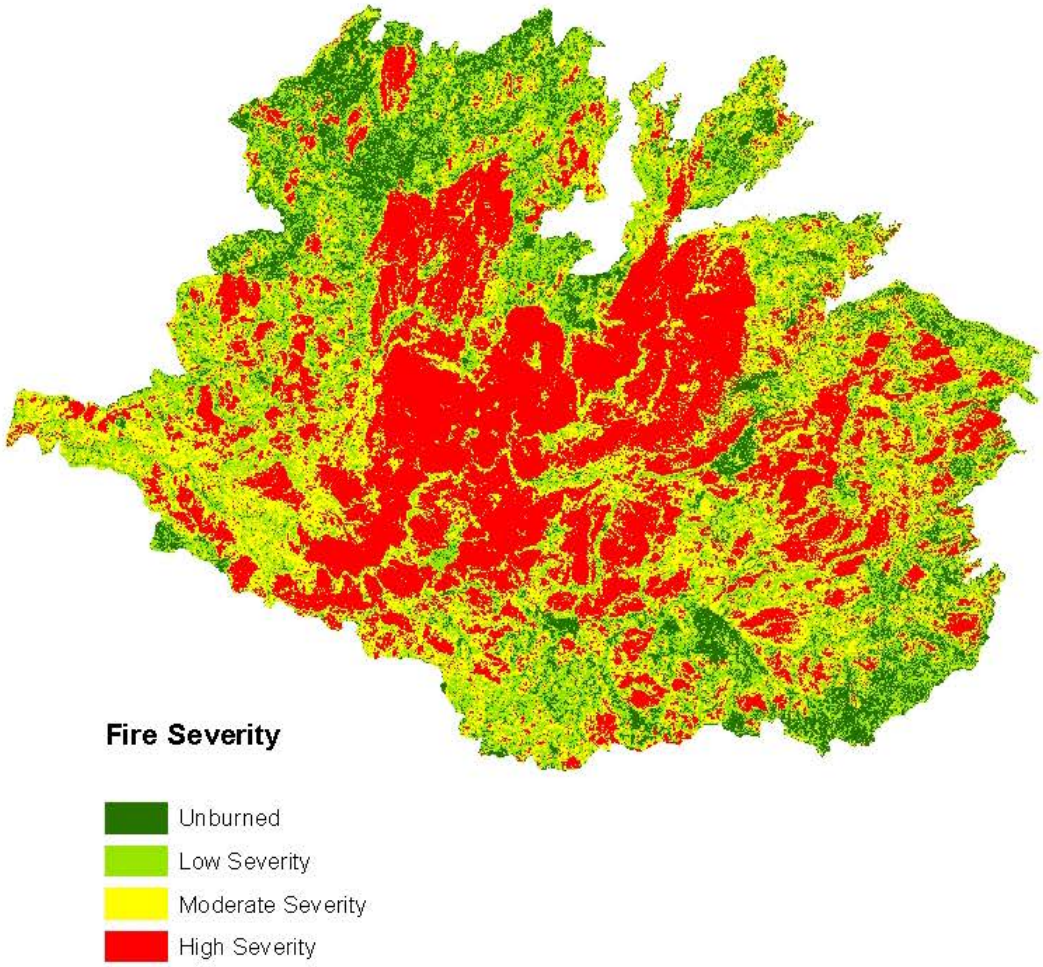


fam_code	Family
A	Dystric Lithic Xerochrepts
B	Dystric Xerochrepts
C	Dystric Xerorthents
D	Entic Cyrumbrepts
E	Fiddletown
F	Gerle
G	Half Dome
H	Holland
I	Humic Dystroxerepts
J	Josephine
K	Lithic Xerumbrepts
L	McCarthy
M	Pinole
N	Rock Outcrop
O	Typic Dystroxerepts
P	Ultic Haploxeralfs
Q	Wintoner
R	Xerolls

Appendix B: Soil Burn Severity of the Rim Fire Area



Appendix C: Vegetation Severity of the Rim Fire Area


Fire Severity
Unburned
Low Severity
Moderate Severity
High Severity

Appendix D: Methodology

SOIL DESCRIPTION AND INTERPRETATION

Soils information for this analysis was derived from the Stanislaus National Forest Soil Survey and obtained from the Natural Resources Conservation Services (NRCS) Web Soil Survey (WSS). The WSS provided both spatial and soil property information used for both field survey and analysis. Specific interpretations and soil data properties were derived from the NRCS Soil Data Viewer (SDV) which is a GIS extension that helps the user analyze soils in a digital environment. Properties derived from the SDV include soil texture, depth, rock fragments, soil taxonomy, soil composition within a unit, and acceptable soil loss.

There were 66 soil map units within the fire area. Because of the size of the fire, a soil map was generated based on dominant soil series in a map unit. A soil map unit is a collection of areas defined and named the same in terms of their soil components (e.g., series) or miscellaneous areas or both. Soil series are families of soils having similar profiles, and developing from similar original materials under the influence of similar climate and vegetation. The soil map is included in Appendix A of this report

SOIL EROSION HAZARD RATING

The Region 5 Soil Erosion Hazard Rating (EHR) System (USDA 1990) was used to rate the risk of soil erosion for all soils in the project area post fire, post implementation and incorporating watershed treatments. 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 following parameters used in the evaluation of EHR are as follows.

- Soil Texture: Derived from SDV based on soil map unit
- Slope Steepness: A 10meter digital elevation model was used to derive the slope ranges used to evaluate EHR. Those ranges are 0-15%, 16-30%, 31-45%, and 46+% slopes.
- Aggregate Stability Adjustment: The only adjustment necessary for aggregate stability is for the alteration of soil structure caused by high soil burn severity.
- Climate: The 2-year, 6-hour value derived from the Precipitation Frequency Atlas of the Western States Atlas, Volume 2.
- Infiltration and permeability: Infiltration is based on soil depth and soil texture which were derived from SDV.
- Runoff from Adjacent and Intermingled Areas: Applied ratings were based on the percentage of rock outcrop and shallow soils within a map unit.
- Soil Cover factors were based on vegetation burn severity maps, Worldview imagery and the forest vegetation layer. For post implementation soil cover, soil cover values were assumed to change little due to increases in activity fuels and cover recruitment from scorched crown. For the watershed treatment areas proposed for Alternatives 3 and 4, cover values were increased to 50% as proposed in management directions. It must be

recognized, however, that the 50% may not be attained in all cases due to lack of available material or fuel objectives not being met.

Erosion Modeling

The Water Erosion Prediction Program (WEPP) Disturbed WEPP batch program (Elliot 2010) was used to model predicted sedimentation resulting from the Rim Fire, salvage activities, and watershed treatments. Disturbed WEPP estimates erosion on an annual basis in contrast to WEPP ERMiT which is a strorm driven model that is useful during the Burned Area Emergency Response (BAER) assessment. WEPP is a physically based erosion model which incorporates topography, soils, climate, vegetation and management activity. Because of the size and complexity of the fire, modeled erosion outputs should not be used as absolute values. The purpose of using modeled values is to illustrate relative risk from existing and management activities and to evaluate the relative change in sedimentation associated with proposed activities. Three batch models were created to model post-fire (existing condition), watershed sensitive area treatments, and salvage logging effects not within watershed sensitive areas. Model inputs were derived as follows and specific attributes can be found in the WEPP batch spreadsheets located in the project record.

- Climate: A modeled climate was developed using Rock:Clim, the WEPP Climate simulator which modified the Hetch Hetchy climate station for climate conditions for the fire area.
- Soil: Soil texture and rock content inputs were acquired from the NRCS SDV and Official Soil Descriptions.
- Topography: Slope ranges were developed by using the 10 meter digital elevation model (DEM) with slope ranges represented by 10%, 30%, 50%, 70% and 90% slope inputs. Slope lengths and shapes were estimated using the DEM to associate slope ranges with topography.
- Treatment/Vegetation:
    - Existing condition: the treatment choice was based on the RAVG classification. If there was no change in canopy, the site was considered an unburnt site and a 20 year forest or shrubland was chosen depending on existing community. If there was a less than 50% canopy change, the low severity fire was chosen for activity. If there was a 50-100% change in canopy, high severity was used.
    - Watershed sensitive areas post implementation: treatments were changed to short grass (Elliot 2013) in those areas with a 50-100%. When analyzed spatially, the watershed sensitive treatments replace the high burn severity salvage logging. All other values in the batch run are superfluous.
    - Salvage actions: For salvage logging operations a short-grass treatment was used (Elliot 2013) regardless of burn severity.
- Cover:
    - Existing conditions: Cover values for the existing condition are generally based on correlations between field observations and the RAVG burn severity. For low or moderated burn severities, soil cover tends to be between 90-100%. For low and moderate burn intensities, cover values were variable, but a conservative value of 30% were used, although during the time of implementation it is likely to be higher due to

soil cover storage in the canopy. For high burn severities, crews generally found little soil cover, especially effective soil cover. Because of standing stems and ongoing windthrow and branch breakage, 10% soil cover was used.

- Watershed sensitive areas post implementation: 50% cover was used based on management direction.
- Salvage actions: Soil cover was reduced by 20% (Elliot 2013) in all treatments except watershed sensitive area treatments where cover was increased to 50% and in areas with high intensity, cover values were increased to 20% to account for addition of activity materials.

SITE OBSERVATIONS

The goals of field observations were to identify soil properties useful in confirming the accuracy of the soil survey and to identify existing soil conditions to help analyze cumulative effects and understand soil response to management. Field observations were also important to correlate the site conditions to remotely sensed data.

Ninety seven plots were recorded. Site observation methods were developed for rapid assessment by field crews. Plot selection was stratified based on burn severity, soil type, topography, and visual satellite imagery expression. Site specific information collected by crews or remotely sensed in GIS include:

Topography: Topography is an important variable when determining erosion/runoff risk, soil moisture content, and ground cover associated with different plant communities. The following data was either gathered in the field or analyzed with digital elevation models on GIS.

- *Slope magnitude and slope shape*: As slope increases, the energy of flowing water increases, thereby increasing soil detachment and transport. Slope shape, whether concave, linear, convex, determines how water is concentrated along a hillslope.
- *Aspect*: The direction a slope faces determines the solar radiation of a hillslope. Plant communities and soil moisture drying rates and temperatures are influenced by aspect.
- *Elevation*: Elevation is a primary determinant on how much and what type of precipitation a soil receives and soil temperature. This influences runoff timing and intensity, plant communities, soil properties, and soil temperature.

Soil Parameters: Several soil parameters were observed to verify soil type and analyze for effects.

- *Soil Texture*: Most soil properties are dependent on soil texture, or the amount of sand, silt and clay. For this project, analysis of compaction and erosion were dependent on soil texture. This property was also used to verify soil type.
- *Soil Depth*: Water storage and potential erosion is dependent on soil depth. Field crews primarily looked at depth classes in the very shallow to deep range.

- *Rock content*: The soils at observation points were broadly characterized as having greater than or less than 35% rock by volume in the upper 20 inches. The higher the rock content, the less prone a soil is to compaction but the higher the runoff and erosion rates are expected to be.
- *Rock Type*: Rock type was broadly identified as granitic, volcanic, and sedimentary. This was used to help the soil scientist verify soil types.
- *Identification of high runoff areas*: Field crews noted the presence of high water runoff areas (shallow soils and rock outcrop). These areas were also identified by review of remotely sensed data. High runoff areas are important to recognize as potential initiation points of erosion in more productive soils downslope.
- *Compaction intensity and disturbance extent*: Field crews examined soil disturbance for compaction. Compaction was evaluated by examining soil structure. Categories included continuous platy structure indicating loss of soil productivity and soil hydrologic function, broken platy structure with vertical root penetration indicating past loss of soil productivity and soil hydrologic function but improving and functioning, and unaltered soil structure indicating little to no compaction. Observations were made on an existing disturbance with the assumption that ground not disturbed is not compacted.

Existing and potential soil cover.
Soil cover is the most important soil characteristic estimate following a wildfire and any subsequent activities post fire. Observations were made to qualify the existing condition and to help watershed personnel correlate multi-spectral imagery with site characteristics. All values of cover were estimated in ranges to allow for rapid assessment.

- *Standing non-commercial wood*: The number of dead trees between 4 and 12 inches were estimated using a standard 1/10th acre plot sample. These trees were estimated to identify material that is available for use in cover either by natural recruitment or active recruitment using mechanical methods.
- *Downed small (1-16”) and large (greater than 16”) wood greater than 10’ long*: The amount of wood on the ground was estimated using a 117’ radius plot (1 acre).
- *Fine Soil Cover and Type*: The percent fine soil cover was estimated visually and includes living and dead plant material. The quality of fine soil cover was also recorded and includes fresh needle fall, duff of mixed decomposition, mixed, straw, or chips.
- *Potential cover type from harvested trees*: A rating system was developed to estimate what type of cover is stored in the standing trees that meet the criteria for harvest. Descriptions include No Branches or Needles at the low end to Large and Fine Branches Present/Heavy Needle Present on the high end.
- *Rock Cover and Type*: The amount of soil covered by rock fragments (2mm-24” in diameter) was visually estimated.
- *Bear Clover*: Bear Clover is important soil surface stabilizing vegetation. Field crews noted the presence of pre-fire Bear Clover and whether it was sprouting post fire.

REMOTELY SENSED DATA ANALYSIS

Analysis for this project utilized several remotely sensed sources of information to identify areas of both soil and vegetation burn severity, tree mortality, disturbances, and potential and existing covers. Unit-by-unit ocular analysis was completed using each of the remotely sensed data sets.

- *Rapid Assessment of Vegetation Condition after Wildfire (RAVG):* The Forest Service Remote Sensing Application Center (RSAC) produced a vegetation burn severity map based on changes in reflectance measured by LANDSaT satellite both before and after the fire. Values provided by RAVG proved to be a good indicator of existing soil cover and soil cover potential.
- *Soil Burn Severity (SBS):* Another product from RSAC, the SBS is a summary rating of soil condition post-fire, 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. For this analysis, SBS was considered in EHR and erosion modeling with respect to structure alteration. However, in erosion modeling, soil cover values interpolated from RAVG were used.
- *LiDAR:* High resolution digital elevation model that was acquired in the fall of 2013. Standard DEMs used by the Forest Service have a resolution of 10 meters. LiDAR, however, has a resolution of 1 meter; a high enough resolution to see existing skid trails with constructed water bars. Figure 2 illustrates the relative differences between a 10 meter and a 1 meter DEM. Note the appearance of the skid trails with constructed water bars in the LiDAR imagery. Figure 2b illustrates an example of mechanical disturbance interpolated from LiDAR imagery.

Figure 2: Comparison of 10m DEM (left) to LiDAR derived 1m DEM (right)

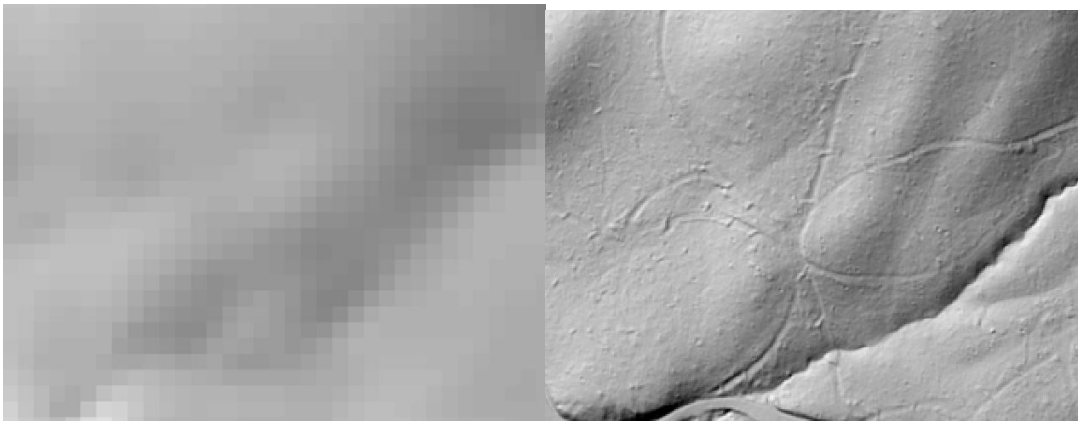
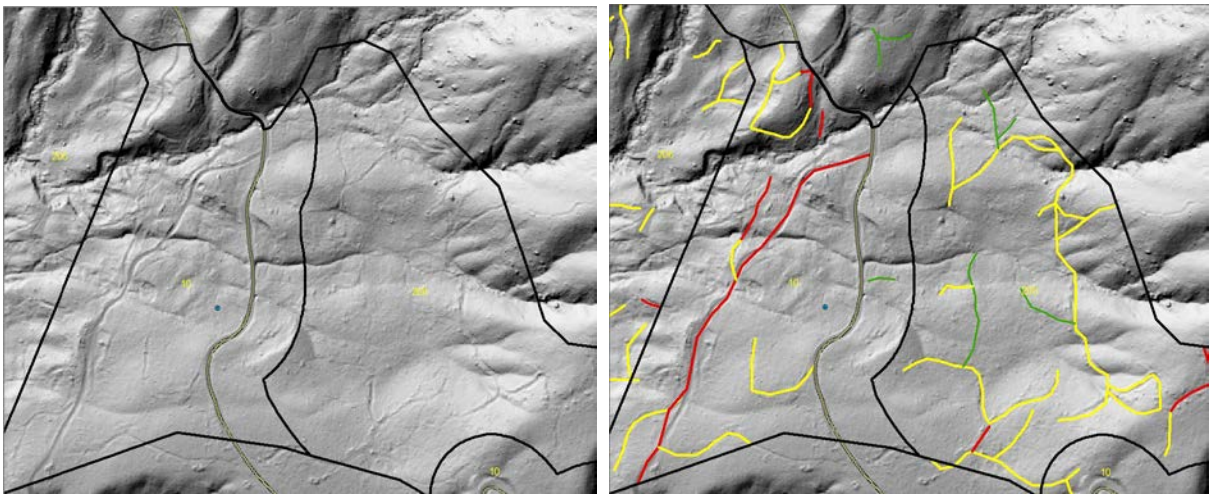
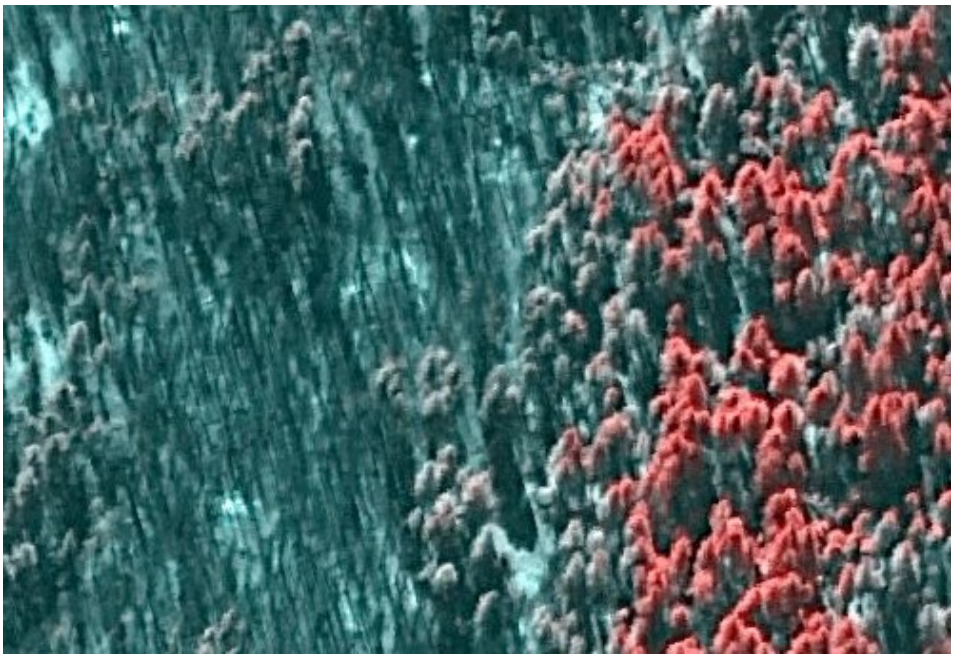


Figure 2b. Mechanical disturbance delineation. Color represents intensity.



- *Worldview/Quickbird Satellite Imagery*: High resolution multispectral imagery produced by DigitalGlobe (sample below). This imagery was extensively used to evaluate the need for watershed treatments and qualify potential soil cover. As seen in Figure 3, red top trees indicate healthy green vegetation that would not be harvested. Brown topped trees are dead trees with retained canopy and a substantial source of soil cover produced during needle fall. Black lines indicated in the imagery are dead trees with full combustion of needles, fine branches and often large branches; these areas are considered deficient in ground cover with a slow predicted recovery. Within the black areas, large woody materials consumed by the fire can be seen as white ash lines and patches.

Figure 3. Worldview imagery illustrating burn severity of the vegetation. Red indicating healthy canopy



WATERSHED SENSITIVE AREAS (WSAs)

Watershed staff examined each unit of the alternatives for areas considered Watershed Sensitive Areas. Watershed Sensitive Areas are portions of the watershed that are at high risk of soil erosion and sedimentation due to the combined effects of the Rim Fire and potential recovery activities. . If post-activity soil cover is not greater than 50% in WSAs, cover additions through dropping non-commercial trees and lopping them into smaller pieces (drop and lop) or masticating the trees into chips or shreds would ensure ground contact.
Criteria for evaluating the existence of WSAs include: proposed recovery activities, burn severity, percent slope and slope shape, slope length, existing and potential soil cover, proximity to intermittent and perennial drainages, and proximity to high runoff response soils.

The following criteria were evaluated as follows:
Proposed recovery activities: The identification of WSAs is dependent on the combined effects of the fire and recovery activities. Only treatment units where ground-based equipment is proposed were considered. This includes tractor units and helicopter and cable-yarding units where feller-buncher type equipment could be used for harvest activities.

Burn Severity: The RAVG product was used as an initial stratification of site conditions. Canopy cover mortalities between 50 and 100% were considered as potentially deficient in soil cover. Both existing cover and immediate future cover recruitment is expected to be deficient.

Topography: The slope range of ground-based activities of 0-35% were considered in the identification of WSAs, however, delineations generally did not occur at slopes less than 15%. Below 15%, Erosion Hazard Ratings are considered moderate or below for all soil types. Bear Gully is the exception due to the identified extreme erosion potential of the terrace soils and the risk to the investment of past restoration activities. Slope shape strongly influences the degree that water concentrates. Slopes that are concave with the contour tend to concentrate water and increases risk that gullies may form below a burned slope. Slope length influences how much water can contributes to runoff and how much energy is accumulated from runoff. Some areas of high burn severity may not have much runoff potential because it burns in a mosaic, which tends to shorten slope lengths. Areas burned in a mosaic were not considered for treatments because the mosaic tends to act as filter areas.

Location of burned areas: The risk to forest resources such as water quality and soil productivity was considered. Most WSA treatments were identified in areas that had close proximity to intermittent and perennial streams so that threats to water quality from cumulative actions could be mitigated by the addition of additional ground cover. WSA treatments were also identified in areas where shallow, high runoff soils generally found on ridgetops were situated immediately upslope of large burned areas.

E. Erosion Hazard Rating: Units that exceed Moderate rating in greater than 15% of the unit (following page).

Alternative 1				Alternative 3				Alternative 4			
A01A	G03A	O04	T27B	A01B	G12	O02A	T27B	A05C	G14B	O06	U01D
A01B	G03B	O05	T28	A03	G13A	O02B	U01B	A08A	G25	O07	U01DX
A02	G04	O06	U01	A04	G13B	O03	U01C	A08C	G26	O08	U02
A03	G05	O07	U02	A05A	G14A	O04	U01D	A09	H01	O09	U03
A04	G06	O08	U03	A05B	G14B	O05	U01DX	A15	H02	O10A	V01
A05	G07	O09	V01	A05C	G25	O06	U02	AA01	H06	O11A	V02
A08A	G08	O10A	V02	A08A	G26	O07	U03	AA03	H09	O11B	V03
A08C	G09	O11A	V03	A08C	H01	O08	V01	AA04	H11	O11C	V04A
A09	G10	O11B	V04	A09	H02	O09	V02	AA07	H11X	O201A	V04B
A10	G11	O11C	V05A	A15	H06	O10A	V03	AA08	H12	O201B	V05B
A15	G12	O201	V05B	AA01	H09	O11A	V04A	AA09	H12X	P201	V10
AA01	G13	P201	V10	AA03	H11	O11B	V04B	AA11	H13A	Q08	V13
AA02	G14A	Q08	V13	AA04	H11X	O11C	V05B	AA12	H13AX	Q09	V13X
AA03	G14B	Q09	V14A	AA07	H12	O201A	V10	AA13	H13B	Q14A	V14A
AA04	G25	Q14A	V14B	AA08	H12X	O201B	V13	B02	H13BX	Q14B	V14B
AA05	G26	Q14B	V14C	AA09	H13A	P201	V13X	B03	HT	Q15	V14C
AA07	H01	Q15	V15	AA11	H13AX	Q08	V14A	B21	K01	Q16	V15
AA08	H02	Q16	W01	AA12	H13B	Q09	V14B	B22	K02	R01B	W01
AA09	H03	R01A	W02	AA13	H13BX	Q14A	V14C	B22X	L01	R04A	W02
AA11	H04	R01B	W03	B02	HT	Q14B	V15	B23	L02A	R04B	W03
AA12	H05	R02	W04	B03	K01	Q15	W01	B24X	L02B	R06A	W04
AA13	H06	R03	W05	B21	K02	Q16	W02	B25X	L02C	R06B	W05A
B01B	H07	R04A	W06	B22	L01	R01A	W03	B32	L02D	R07A	W06A
B02	H08	R04B	X01	B22X	L02A	R01B	W04	C02	L02E	R07B	W06B
B03	H11	R06A	X02	B23	L02B	R02	W05A	C03	L03	R12	X01A
B21	H12	R06B	X03	B24X	L02C	R04A	W06A	C04X	L04	R12X	X01B
B22	H13A	R07	X04	B25X	L02D	R04B	W06B	C05	L05A	R15	X02
B23	H13B	R08	X05	B32	L02E	R06A	X01A	D01B	L05B	R16	X03
B24	HT	R12	X06	C02	L03	R06B	X01B	D01C	L07	R17X	X04
B25	K01	R15	X07	C03	L04	R07A	X02	D01E	L201	R18	X05
B32	K02	R16	X08	C04X	L05A	R07B	X03	D04A	L202	R18X	X06
B33	L01	R17	X09	C05	L05B	R12	X04	D04B	L203	R19A	X07
C02	L02A	R18	X10	D01A	L07	R12X	X05	D05	L204	R19B	X08
C03	L02B	R19A	X100	D01B	L201	R15	X06	D08	L205	R19D	X09
C04	L02C	R19B	X101	D01C	L202	R16	X07	D09	L206	R19DX	X10
C05	L02D	R19D	X102	D01E	L203	R17X	X08	D11	M01	R19F	X100
D01A	L03	R19F	X103	D04A	L204	R18	X09	D12	M02A	R20	X101
D01B	L04	R20	X104	D04B	L205	R18X	X10	D13	M04A	R22	X102
D01C	L05A	R22	X106	D05	L206	R19A	X100	E03A	M05A	R23	X103
D01E	L05B	R23	X107	D08	M01	R19B	X101	E03B	M05B	R24A	X104
D04A	L06	R24A	X108	D09	M02A	R19D	X102	E04	M05C	R25X	X106
D04B	L07	R24B	X109A	D11	M04A	R19DX	X103	E05	M05D	R31	X107
D05	L202	R25	X109B	D12	M05A	R19F	X104	F01	M05E	R31X	X108
D08	L203A	R31	X109C	D13	M05B	R20	X106	F02A	M05F	R32	X109A
D09	L203B	R32	X109D	E01A	M05C	R22	X107	F02B	M05G	R33X	X109B
D11	L204A	R33	X109E	E01B	M05D	R23	X108	F03	M06	R35A	X109C
D12	L204B	R35	X11	E02	M05E	R24A	X109A	F11	M07	R35B	X109D
D13	L205	R36	X110	E03A	M05F	R25X	X109B	F12	M08A	R36	X109E
E01A	L206	R37	X111	E03B	M05G	R31	X109C	F13	M08B	R37	X110
E01B	M01	R38	X112	E04	M06	R31X	X109D	F14	M08C	R38	X111X
E02	M02A	S01	X114	E05	M07	R32	X109E	F15	M08D	R40B	X112
E03A	M04A	S02	X115	F01	M08A	R33X	X110	F16	M08E	S01	X114X
E03B	M05A	S03	X116	F02A	M08B	R35A	X111X	F17	M09	S02	X115
E04	M05B	S04	X117	F02B	M08C	R35B	X112	F18	M10	S03	X116
E05	M06	S05A	X118	F03	M08D	R36	X114X	F19	M12	S04	X117
E06	M07	S05B	X119	F11	M08E	R37	X115	F20	M13	S06	X118
F01	M08A	S06	X12	F12	M09	R38	X116	F21	M15	S08	X118X
F02A	M08B	S08	X120	F13	M10	R40B	X117	F22A	M16B	S10	X119X
F02B	M08C	S10	X13	F14	M12	S01	X118	F22B	M18	S11	X12
F03	M08D	S11	X14	F15	M13	S02	X118X	G01	M19	T01	X120
F11	M08E	T01	X15	F16	M15	S03	X119X	G01X	M20	T02	X13
F12	M09	T02	X16	F17	M16B	S04	X12	G02X	M201	T03	X15
F13	M10	T03	X17	F18	M18	S06	X120	G03A	M202A	T04A	X16
F14	M12	T04A	X18	F19	M19	S08	X13	G03B	M202B	T04B	X17
F15	M13	T04B	X19	F20	M20	S10	X15	G04	M203	T04C	X18
F16	M15	T04C	X22	F21	M201	S11	X16	G05	M204	T04D	X19
F17	M16B	T04D	X23	F22A	M202A	T01	X17	G06	N01A	T04E	X22
F18	M18	T04E	X24	F22B	M202B	T02	X18	G07	N01B	T20	X23
F19	M19	T20	X25	G01	M203	T03	X19	G08	N01C	T21B	X24
F20	M201	T21B	X26	G01X	M204	T04A	X22	G08X	N01D	T23	X25
F21	N01	T23	X27	G02X	N01A	T04B	X23	G09	N01E	T23X	X26
F22A	N02	T24	X40	G03A	N01B	T04C	X24	G10	N01F	T24	X27
F22B	N03	T25	X41	G03B	N01C	T04D	X25	G11A	N01G	T25	X40
G01	O01	T26	Y01	G04	N01D	T04E	X26	G11B	N01H	T25X	X41
G02	O02	T27A	Y02	G05	N01E	T20	X27	G11C	N01I	T26	Y01A
	O03		Y03	G06	N01F	T21B	X40	G12	N01J	T27A	Y01B
				G07	N01G	T23	X41	G13A	N02A	T27AX	Y01C
				G08	N01H	T23X	Y01A	G13B	N02B	T27B	Y01D
				G08X	N01I	T24	Y01B	G14A	N03	U01B	Y02
				G09	N01J	T25	Y01C		O03	U01C	Y03A
				G10	N02A	T25X	Y01D				Y03B
				G11A	N02B	T26	Y02				
				G11B	N03	T27A	Y03A				
				G11C	O01	T27AX	Y03B				