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Rim Fire Reforestation (45612)

Soils Resource Report

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1. Introduction

This report contains the specialist review of soil resource conditions in the Rim Fire Reforestation project area, which is located within the Rim Fire perimeter within portions of the Mi-Wok and Groveland Ranger Districts on the Stanislaus National Forest (T3N-T2S, R16E-R19E; Mount Diablo Base and Meridian). The project area includes all NFS lands within the fire, which burned between 1,000 to 7,000 feet in elevation in a mixed severity mosaic pattern through all its principal vegetative communities.

Based on the Forest Plan Direction, the overall purpose of the Rim Reforestation project is to: create a fire resilient mixed conifer forest that contributes to an ecologically healthy and resilient landscape rich in biodiversity. Chapter 1 of the Draft EIS describes the desired future conditions of the Rim Fire landscape which would have an increased capacity to adapt and survive natural disturbances, especially under changing and uncertain future environmental conditions, such as those driven by climate change and human use. Five specific needs for this project were developed, and are based on Forest Plan Direction.

- Return Mixed Conifer Forest to the Landscape
- Restore Old Forest for Wildlife Habitat and Connectivity
- Reduce Fuels for Future Fire Resiliency
- Enhance Deer Habitat
- Eradicate Noxious Weeds

1.01 PROPOSED ACTION SUMMARY

The proposed actions are intended to work towards the desired conditions and needs within the project area. Five alternatives are being analyzed to work towards the desired resource conditions. Table 1.01-1 includes a summary of proposed treatments for all alternatives.

Table 1.01-1 Comparison of Alternatives by Proposed Action

Proposed Treatments (acres)	**Alternative 1** (Proposed Action)	**Alternative 2** (No Action)	**Alternative 3**	**Alternative 4**	**Alternative 5**
Deer habitat enhancement	3,833	0	3,833	1,164	3,833
Natural regeneration	4,031	0	4,031	22,464	0
Noxious weed eradication	5,714	0	3,131	3,131	5,714
Reforestation	21,300	0	21,300	2,867	25,331
Thin existing plantations	12,769	0	12,769	12,769	12,769
Prescribed fire only	0	0	0	34,344	0

1.02 MANAGEMENT REQUIREMENTS

Soil Requirements common to all action alternatives

1) Follow Forest Service Manual 2550 Soil Management R5 Supplement (USDA, 2012) and Forest Plan Direction (USDA, 2010) to identify Soil Management Practices (SMPs) that minimize soil impacts.

a) Limit skidding with rubber-tired or fixed track equipment to slopes less than 35%; limit low ground pressure tracked equipment (e.g. masticator or feller buncher) to less than 45%; limit dozer piling and other (non-deep tilling) mechanical site preparation to less than 30%, or less than 25% on soils with Erosion Hazard Ratings higher than moderate.
b) Replace or recontour soil when excessive soil displacement occurs.
c) The soil scientist will monitor ground-based operations occurring between November 1 and June 1 (test for soil moisture and traffic-ability). Ground-based equipment will operate on relatively dry soils of high soil strength, or bearing capacity to prevent soil compaction.
d) Maintain a well-distributed soil cover of 50% after site preparation, prescribed fire or release treatments on slopes less than 25%. Maintain 60% cover on steeper slopes and within Riparian Conservation Areas (RCAs). Soil cover consists of duff and litter, basal live plant cover, fine woody debris, surface rocks, and downed logs. Deep tilling (subsoiling) and forest cultivation site preparation treatments are excluded from this requirement and fuel's requirements also take priority in order to ensure fuels reduction on these sites.
e) Where existing ground cover is less than desired, some trees may be felled and left in place or masticated into pieces less than 2 feet in length to reduce potential soil erosion and maintain soil productivity.

2) Mechanical Site Preparation
   a) Use a brush rake for all dozer piling work. Keep the blade about 6 inches above ground level to prevent soil, litter, and duff material from being piled. Piles should be relatively free of soil (less than 10% soil material), and will be re-spread and rebuilt if they do not meet these specifications.
   b) For deep tilling, ensure that contract specifications plan include the maximum depth of furrowing, a requirement for backblading when the depth of furrowing is exceeded, and winged ripper tool design specifications.
   c) Perform deep tilling when soils are below their plastic limit throughout the top 18 inches. The soil should crumble when attempting to form a 'ribbon' or roll a thread. In addition, for areas with heavy clay content, do not perform deep tilling when soil is dry; this will allow for proper fracturing of soil without creating excessive disturbance. Examples of soils with heavy clay content include: Jocal (Josephine), Sites, Stump Springs, Musick, and Hoda.
   d) Deep till along the contour with slope measured in deep tilled furrows being less than 5%. If contour deep tilling cannot be achieved in some areas, select these as sites for vegetated buffer strips.
   e) Leave a no-till strip below drainage outlets.

Soil Requirements for Alternative 1

1) Deep Tilling and Forest Cultivation
   a) On slopes over 20%, maintain at least one 8 to 10-foot vegetated buffer strip for every 100 feet of contour deep tilling or forest cultivation; this area can overlap with the unplanted rows or areas in planting design. In units with only portions identified that are suitable for deep tilling, consult with a soil scientist to assist in delineating these areas on the ground before the work begins.
   b) For deep tilling units with slopes greater than 15%, leave a buffer strip of 12 feet on the downhill side of roads that may concentrate water and drain onto a deep tilled unit.
   c) Deep till followed by forest cultivation on less than 30% slopes.

Soil Requirements for Alternative 3

1) Deep till followed by forest cultivation on less than 35% slopes.

Soil Requirements for Alternative 4

This alternative only includes management requirements common to all action alternatives.

Soil Requirements for Alternative 5

1) Deep till followed by forest cultivation on less than 35% slopes.
2) On slopes over 20%, maintain at least one 8 to 10-foot vegetated buffer strip for every 100 feet of contour deep tilling or forest cultivation; this area can overlap with the unplanted rows or areas in planting design. In units with only portions identified that are suitable for deep tilling, consult with a soil scientist to assist in delineating these areas on the ground before the work begins.
3) For deep tilling units with slopes greater than 15%, leave a buffer strip of 12 feet on the downhill side of roads that may concentrate water and drain onto a deep tilled unit.

2. Affected Environment and Environmental Consequences

2.01 FRAMEWORK

Analysis Framework: Statute, Regulation, Forest Plan and Other Direction

National Forest Management Act (NFMA) of 1976 as amended and the Forest and Rangeland Renewable Resources Planning Act of 1974) require 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.

Forest Service Manual (FSM) 2550 (USDA 2010b) establishes the management framework for sustaining soil quality and hydrologic function while providing goods and services outlined in the Forest Plan. Primary objectives of this framework are to inform managers 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 used to determine if soil quality conditions and objectives have been achieved.

Pacific Southwest Region (Region 5) FSM 2500 Chapter 2550 Supplement (USDA 2012b) establishes soil functions (support for plant growth (productivity) function, soil hydrologic function, and filtering and buffering function) that the Region uses to assess soil conditions and determine if the national soil quality objectives are being met. Each soil function has a set of indicators that frame the desired condition for soil resources. The analysis standards are 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.

Forest Service Handbook (FSH) 2509.22, Chapter 10 (Water Quality Management Handbook) (USDA 2011a) improves and replaces the Best Management Practices (BMPs) presented in Water Quality Management for NFS lands in California. The Forest Service water quality protection program relies on implementation of prescribed BMPs. These BMPs are procedures and techniques that are incorporated in project actions and 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. Additionally, the 2011 Handbook amendment establishes an expanded water quality management monitoring program (section 16).

National Best Management Practices for Water Quality Management on National Forest System Lands (USDA 2012a) apply to the proposed activities and are included in Chapter 2.

The Forest Plan Compliance (project record) document identifies the Forest Plan Standards and Guidelines that specifically apply to this project and related information about compliance with the Forest Plan.

Effects Analysis Methodology

Soil effects are determined and predicted based on a review of relevant literature and from monitoring reports and observations of soils where similar actions have occurred in the past. While the physical actions may be similar, the impact to soils depends on the soil properties at that location, which can be highly variable. The analysis area for this report consists of soil that supports vegetation growth within the project area boundary. Soils under roads, trails, and recreation sites are not directly considered when addressing soil impacts from the project, but their indirect effects on soils

supporting vegetation are considered where necessary (e.g. runoff from roads that leads to erosion in a treatment unit).

The soil effects analysis is bounded in time by the foreseeable future period during which detectable effects on the soil resource could persist in this project area. Some soil features, such as ground cover, can recover quite quickly. Effects on other features, such as compaction and soil organic matter, can persist for decades or centuries. Because soil effects can be persistent, the current soil conditions reflect the cumulative effects of past activities, regardless of when they took place. In general, effects are discussed as short-term (less than 5 years) or long-term effects (longer than 5 years). For cumulative effects, the analysis is bounded in time by past, present and reasonably foreseeable future projects.

Assumptions Specific to Soils

- Activities detailed in the Rim Fire Recovery EIS (USDA 2014) are still in progress. However, for soil effects analysis, the baseline condition will assume that all activities in both the Rim Recovery and Rim Fire Hazard Trees EA (USDA 2014c) projects have already taken place.
- All treatments prescribed under the natural regeneration units were assumed to be implemented in order to analyze for the most potential impacts.
- The condition of ground cover will be determined by currently proposed mechanical site preparation or prescribed burn treatments. In alternatives that contain units with only herbicide proposed for site preparation, past actions such as machine piling in combination with herbicide site preparation will determine future soil cover.
- Assumptions for Erosion Hazard Rating (EHR) analysis include:
    - All slopes are uniform and were generalized by soil type.
    - For EHRs, a single “climate” was used for the whole project area. The precipitation values were based on a weather station close to Corral Creek, near the middle of the Rim Fire.
    - Soil Cover inputs to the EHR analysis are estimates of percent ground cover that would be remaining after proposed treatment activities (e.g. site preparation) are complete. Estimated cover values were based on field surveys, ground cover data, and photographs of similar treatment types that have occurred on the Stanislaus in the past.
    - The EHRs include a factor to increase water infiltration for units that could receive deep till and forest cultivation (DTFC) treatments.

Data Sources

- Soil survey data including maps and soil properties from the Stanislaus National Forest Soil Survey (USDA 1981), and more detailed soil surveys covering portions of the project area (Norgren et al. 1990).
- Soil interpretations provided by the Region 5 Soil Interpretation Guide (USDA 1999).
- The Rim Fire Soil Burn Severity map and soils BAER report (Flores et al. 2013).
- Remote sensing data including the LiDAR DEM, and high resolution multi-spectral imagery acquired and processed in 2013 by the Forest Service Remote Sensing Lab based in McClellan, California.
- Geologic map of Tuolumne and Mariposa counties, and associated GIS layers.
- Soil pit descriptions, and additional field observations about soil disturbance and soil physical properties made by the soil scientist and field crews.

Soils Indicators

The Region 5 supplement (USDA 2012b) to the national soil management chapter provides direction for soil assessment procedures and defines the soil functions and indicators that were used to frame soil condition assessments. Three soil functions (environmental functions of soil) were used for

assessment and analysis to determine if the national soil quality objectives were being met: support for plant growth function (soil productivity); soil hydrologic function; and filtering-buffering function. Each of these 3 functions has a set of indicators, listed below, that were used to determine if existing conditions meet the desired soil conditions in the project area.

SOIL STABILITY

- Amount of unit with EHR higher than moderate
- Amount of soil cover removed by project activities

SURFACE AND SOIL ORGANIC MATTER

- Percent organic mulch cover remaining after site preparation (Criteria greater than 50% area covered)
- Area of productivity loss due to displacement of topsoil

SOIL STRENGTH AND STRUCTURE

- Area of productivity loss due to compaction or loss of soil porosity
- Area with reduced infiltration due to change in soil structure

SOIL MOISTURE REGIME

- Soil moisture regime in meadows and fens is retained

FILTERING BUFFERING FUNCTION

- Soil microorganism populations
- Leaching potential of applied herbicides
- Risk of off-site movement of applied herbicides

The indicators above include the following specific measures. Soil stability refers to a soil's ability to resist erosion. Soil cover protects a soil from water and wind erosion, and slope, vegetation type and infiltration rates all affect the overall risk of erosion. The EHR method incorporates all these factors to show relative differences in soil stability. To preserve soil stability, soil cover should be managed to avoid a high EHR (USDA 1999) after project activities are complete. For surface organic matter, an organic mulch consisting of duff and small woody debris should cover approximately 50% of the soil surface after site preparation, and 85% of soil organic matter should be preserved in the top 12 inches of soil (USDA 2010a). Soil porosity and soil structure should be maintained similar to the natural condition to maintain a favorable rooting environment for plants and to ensure sufficient infiltration rates to accommodate precipitation inputs (USDA 2012b). Soil moisture regimes should not be altered from their natural state, especially in wet meadows and fens (USDA 2012b). Lastly, no specific measures for soil filtering buffering function have been developed. Instead, the Region 5 Soil Management Handbook Amendment (USDA 2012b) states: for projects that involve the application of chemicals, such as herbicides, analyze the effects to soil micro-organisms, post-project erosion risk, leaching potential and risk of off-site movement of the chemicals.

Soils Methodology by Action

There are various types of activity groups proposed in this project that are performed with mechanical equipment or prescribed burning that have similar effects on soil: deer habitat enhancement, natural regeneration, reforestation (non-mechanical site preparation, plant conifers, prescribed fire, grubbing), and thin existing plantations. Tree thinning and prescribed burn actions for the purpose of deer habitat enhancement or for plantation thinning occur in different locations across the landscape, but have similar effects on soil; thus they were analyzed together in this section. Effects from mechanical site preparation, herbicide site preparation, and herbicide use for noxious weed eradication are all discussed separately.

SOIL DESCRIPTION AND INTERPRETATION

Soils information for this analysis was derived from the Stanislaus National Forest Soil Survey, the NRCS Soil Data Viewer (SDV), and from more detailed soil surveys covering portions of the project area (USDA 2008b; Norgren et al. 1990). The SDV was used to review distribution of specific soil properties potentially affected by mechanical equipment operations on a unit-by-unit basis. Specific interpretations and soil data properties from the SDV include soil texture, depth, rock content, soil taxonomy, infiltration and permeability, soil water holding capacity, soil composition within a unit, acceptable soil loss, slope percent, and soil productivity information such as soil survey site class or Net Primary Productivity. The analysis of these data was used, partly, to determine where various mechanical site preparation techniques would occur. Appendix A, Map 2 includes a soil map.

SITE OBSERVATIONS

Field observations identified soil properties useful in confirming the accuracy of the soil survey, existing soil conditions, and soil response to management activities. Sampling in 2015 focused on important soil variables to determine how soils would respond to site preparation and herbicide treatments; variables sampled include soil depth, rock content, slope, surface rock outcrop, soil texture, ground cover, and soil hydrologic group. The predicted level of treatment impact, focusing on units with tractor piling and DTFC treatments first, was used to prioritize unit sampling. Twenty-five units proposed for DTFC treatments were visited and more than 250 plots and soil pits were recorded.

Additionally, site observations from 2013, acquired after the Rim Fire, supplemented the 2015 sampling. Because of ongoing salvage logging activities, some properties have changed since the sampling occurred (such as ground cover), and do not represent the existing condition; however, soil properties such as depth, hydrologic group, slope, texture, and rock content are still useful. Ninety-seven plots from 2013 were used.

Pre-harvest soil disturbance data were collected in areas covered by the Rim Hazard Tree EA project using the protocol described by Page-Dumroese et al. (2009). Only limited data about soil disturbance after completion of the Hazard Tree project are available, including 11 transects. No soil disturbance data have been collected yet in the Rim Recovery salvage logged areas.

SOIL EROSION HAZARD RATING

The Region 5 Soil EHR System (USDA 1999) was used to rate the risk of erosion for all soils in the project area after implementation of project activities. This system uses various physical soil properties along with climate and site-specific conditions to rate sheet and rill erosion soil hazards. Inputs to the EHR system were adapted to best fit the predicted conditions after project activities were implemented. Soil cover inputs were derived from observed field data for the no action alternative. For action alternatives, monitoring data from similar past treatments was used to predict soil cover post-treatment.

LIDAR DATA ANALYSIS

A digital elevation model (DEM) derived from LiDAR data was used to create 1-meter slope layers, aspect and a hill shade layer that was used to visually inspect units for rock outcrops. These data were used in the unit-by-unit assessment of suitability for site preparation techniques, and as inputs to the EHR analysis.

2.02 AFFECTED ENVIRONMENT

Soil Properties

The geology within the Rim Fire includes variable metamorphic rocks in foothill formations, volcanic mudflows and conglomerates on ridge locations, and young glaciated or old deeply-weathered

granitic rocks throughout the area. Project area soils are primarily derived from metamorphic rock in the lower elevations and granitic rock at mid and higher elevations. Table 3.11-2 displays the general soil groups in the project area and the corresponding soil properties used in the analysis. A generalized soil map is available in Appendix A, Map 2. Most soils within the analysis area have surface textures of loam or sandy loam with gravelly texture modifiers, and the most abundant soils have clay loam subsurface textures. This indicates soils with high natural infiltration rates at the surface, but only moderate permeability or ability to transmit water below ground. These soils range from shallow to deep, reflecting a wide range of soil productivity and soil hydrologic groups. Specific dominant soils include 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.

Table 2.01-1 Soil Families and Associated Properties Used in Analysis

Family	MAE (%)	T-FAC	Surface Texture	SubsurfaceTexture	Depth (inches)	COMP Hazard	Rock (%)
Dystric Lithic Xerochrepts	2.0	1	Cobbly loam	Cobbly loam	20-40	Moderate	10-50
Dystric Xerochrepts	0.50	1	Cobbly loam	Coarse sandy loam	20-40	Moderate	0-25
Fiddletown	8.3	2	Gravelly-Bouldery sandy loam	Gravelly sandy loam	20-60	Slight	35-60
Gerle	4.0	4	Gravelly sandy loam	Sandy loam	40-60+	Slight	5-30
Holland	32.4	4	Loam	Clay loam	40-80+	Severe	5-20
Josephine	29.1	4	Gravelly loam	Clay loam	20-60+	Severe	10-30
Lithic Xerumbrepts	5.1	1	Loamy sand	Sandy loam	0-20	Slight	10-50
McCarthy	5.2	3	Gravelly sandy loam	Sandy loam	20-60	Slight	35-60
Pinole	0.4	4	Gravelly loam	Clay loam	60-80+	Severe	5-35
Rock Outcrop	.28	1	Unweathered bedrock	NA	0-10	Slight	
Sites	4.54	2	Gravelly loam	Gravelly clay loam	20-80+	Severe	0-25
Typic Dystroxerepts	0.2						
Ultic Haploxeralfs	.50	1	Sandy loam	Loam		Severe	0-10
Wintoner	7.6	4	Gravelly loam	Clay loam	40-60+	Severe	0-30
Xerolls	0.1	5	Loam	Loam	40-60+	Severe	0-15

MAE= Maximum Extent of Activities (% of total acres); T-FAC= T-Factor; COMP= Compaction; Rock= Rock Content

The majority of soils (about 75%) within the proposed action have a severe compaction rating (high probability to be compacted by activities when moist). These tend to be the most productive soils in the project area, particularly the Holland and Josephine soils.

Existing Conditions

The project area occurs entirely within the footprint of the 2013 Rim Fire. The soil burn severity within the Rim Fire was approximately 44% high and moderate soil burn severity, and the rest at low or very low burn severity. Immediately after the fire, the high and moderate burn severity areas had a deficiency of both soil cover and surface organic matter. Two years after the fire, substantial vegetation regrowth occurred in many locations, but the regrowth is variable. In some locations, native shrub species including some nitrogen-fixing species have produced significant ground and canopy cover. Some areas with high soil burn severity have less vegetation growth or have a cover of invasive species that are not providing the same protective soil cover. In short, recovery of vegetation is variable, leaving some locations vulnerable to erosion. The amount of soil organic matter lost in the fire has not recovered in two years, and any pre-fire soil disturbance causing compaction or displacement on major skid trails has not changed. In locations where no management actions have occurred in the last 2 years, the fire is still one of the dominant features controlling surface soil

conditions. Existing conditions immediately post-fire were described in further detail in the Rim Recovery EIS, Chapter 3.11 (USDA 2014).

The Rim Fire hazard tree removal and salvage logging activities affected multiple soil indicators. The EHR method reflects changes made to soil cover and stability. Project-wide, EHR conditions range from low to moderate with 41% of the project area predicted to have a low EHR and 59% predicted to be moderate. This is an improvement in EHR conditions as described in the BAER report and Rim Recovery EIS. The improvement is primarily due to increases in ground cover since the fire. Data from 2014 soil disturbance monitoring at 11 Rim Hazard Trees sites showed ground cover ranged from 62 to 87% with an average of 78%. Sampling in 2015 showed ground cover ranged from 35 to 85%, and averaged 60%. In short, ground cover within salvaged logged areas varies widely and is difficult to rate for the whole project, but it is currently sufficient in most areas to prevent a high EHR.

Results of soil disturbance monitoring reflect changes in other soil indicators including surface and soil organic matter (SOM), and soil strength and structure. In 2013, remote sensing analysis and field validation was done to identify legacy, or historic evidence of soil disturbance. While the skid trail footprint and levels of compaction have likely changed since 2013 due to salvage logging, the SOM lost due to displacement on those trails or combustion during the fire remains the same (in other words, the SOM has not recovered in 2 years). The most severe legacy compaction was found on benched skid trails or temporary roads on Josephine and Holland soils where clay subsoils were exposed and vegetation was stunted or non-existent. This reflects a reduction of soil porosity and displacement of the soil organic material. This, combined with SOM lost in combustion during the Rim Fire led to approximately 6,000 acres with reduced levels of SOM (USDA 2014 Soils Chapter 3.11). In 2014, sampling showed that 3 of the 11 units sampled, or 27%, exceeded disturbance thresholds and are expected to have a loss of soil productivity. Units typically exceeded thresholds as a result of excessive displacement and loss of SOM, or had excessive compaction. Sampling in 2015 showed that 9 out of 24 units sampled showed some sign of erosion evidence, and 7 units (or 29%) showed evidence of rill or gully erosion sufficient to have a loss of productivity. Additional data about soil disturbances was not collected in 2015.

Disturbance sampling in 2014 was only done in Rim Hazard Trees project areas, and no data were collected in Rim Recovery salvage logged areas as methods for hazard tree removal are very similar to salvage logging. Although the sample sites were well-distributed throughout the project area, the sample size was small. The 2014 disturbance data are assumed to reasonably represent the conditions found in Rim Recovery treatment areas, but not enough data are available to rate the existing condition of soil indicators on a unit basis, or by activity groups. Instead, existing indicator ratings are provided below in Table 3.11-2 for the whole project area based on the best available data. Additional disturbance data may be collected between the Draft and Final versions of this document. More information about the predicted effects of Rim Recovery treatments can be found in the Rim Recovery Final EIS, Soils Chapter 3.11.

Table 2.02-1 Summary of Existing Condition of Indicators

Soil Function	Indicator	Rating Range	Metric[1]	Area
Soil Productivity and Hydrologic Function	Soil Stability	Good	EHR greater than moderate	0 units (0 acres)
Soil Productivity and Hydrologic Function	Soil Stability	Poor - Good	Presence of rill and gully erosion	7 units (29% of units)
Soil Productivity	Surface and Soil Organic Matter	Fair - Good	Percent ground cover, average project-wide	69%
Soil Productivity	Surface and Soil Organic Matter	Fair - Good	Percent of units sampled not meeting organic mulch cover requirement	17% of units
Soil Productivity	Soil Strength and Structure	Poor - Fair	Area with soil productivity loss due to compaction or displacement	27% of units
Soil Productivity	Soil Strength and Structure	Poor - Fair	Acres of productivity loss (legacy disturbance) post-fire	6,062 acres

[1]Source: Rim Recovery EIS, Soils Chapter 3.11

2.03 ENVIRONMENTAL CONSEQUENCES

Environmental consequences are discussed by the proposed treatment types. The action categories of deer habitat enhancement, natural regeneration, thin existing plantations, and reforestation in some cases use similar treatment types to achieve the objectives described, so discussions are grouped together by treatment type. As stated above, all treatments under the natural regeneration units were assumed to be implemented, so analysis related to all reforestation treatment types also applies to natural regeneration units. Discussions for each soil indicator include assessments for: mechanical and hand thinning of trees (including initial site preparation), prescribed fire (including pile burning), mechanical site preparation (machine pile, DTFC etc.), manual release, and chemical site preparation and release. The act of conifer planting has minimal direct effects on all soil indicators, and is not discussed further. However, the density of planted trees and their contributions to soil moisture, cover and organic matter over time are important, and are discussed where appropriate. Noxious weed eradication treatments and chemical site preparation or release are discussed together.

Alternative 1

Direct and Indirect Effects

SOIL STABILITY

In existing plantations proposed for tree thinning, soil cover would be reduced, especially on landings and main skid trails. In past monitoring of thinning-only treatments in a similar environmental setting, total soil cover typically remained high enough to meet forest standards and prevent a high EHR (McComb and Westmoreland 2006). In Alternative 1, most thinning units would also have prescribed understory burning implemented before thinning. Burning in combination with thinning would cause an initial reduction in soil cover due to organic horizon combustion. However, with typical spring or fall burning and associated high fuel moistures, this reduction would likely be within forest soil quality guidelines for cover. EHR analysis shows that in thin or thin and burn units, no areas would result in a high EHR.

A - Glyphosate release spray

B - Hand grubbing, only 2.5 foot radius

C - Dozer piling only

D - Dozer piling, followed by DTFC

Figure 2.03-1 Surface Organic Mulch After Different Treatments.

Mechanical site preparation done with feller bunchers, mastication, or grapple piling would have effects similar to those of thinning alone, except most units would not have prescribed burning done first. Mastication treatments would increase soil cover through additions of shredded tree and shrub material. Burning of any piles created would reduce soil cover immediately under the piles, but the area would likely be small relative to the unit size. Mechanical site preparation could also be done with dozers or tractors with brush rakes used to push material into piles for burning. Dozer 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 would be displaced to piles. Recent and past monitoring of dozer piling shows that it can reduce soil cover well below forest standards in the short term, making sites more susceptible to erosion, but the result is highly dependent on vegetation type and ground cover. In a recently monitored tractor piled unit, a young plantation burned in the Rim Fire, ground cover averaged only 36%. But two other units with a heavy component of manzanita (one burned, and one unburned) both had ground cover above 60% after treatment (Figure 3.11-1, C). EHR analysis shows only 6 units, or about 94 acres would be moved to a high EHR as a result of tractor piling.

The final mechanical site preparation method is deep tilling followed by forest cultivation. Monitoring of this treatment on the Stanislaus done in the 1990’s and in 2015 show that ground cover is typically reduced considerably, sometimes below 20% (Brown 1993; Griffith et al. 1990; Schmitt 1997). Cover is not typically moved off site, but is incorporated into below ground soil layers so it

has less benefit to preventing erosion and stabilizing soil (Figure 3.11-1, D); this condition would remain until vegetation and planted trees produce ground cover sufficient to prevent erosion. Monitoring by Ed Brown (1993) stated 62% of the sampled units showed "localized sheet and rill erosion characterized by gravel pavements, sediment basins, puddles and rill channels." In this monitoring, the majority of the erosion occurred on soils with higher clay content. More rarely, severe rilling or gullying has been recorded on DTFC units, usually below road drainages that concentrate water onto loosened soil.

The monitoring of DTFC units in the 1990's recommended practices to limit or prevent erosion on this treatment, and many of these recommendations have been built in to management requirements for Alternative 1. Two soil types that most commonly showed severe erosion after DTFC treatments were Mariposa and Bandarita soils (Schmitt 1997). In Alternative 1, these soils were avoided as much as possible when assigning DTFC as a site preparation treatment. On steeper slopes, the untilled vegetated buffer strips left below road drainage outlets and every 100 feet along the slope would provide material to capture and keep eroded soil on site and would help break up rill networks, if they were to form. With the soil management requirements, 116 units in Alternative 1 would have their EHR increased to high. This is a large increase in high EHR ratings compared to the existing condition and Alternative 2 (no action), but compared to other action alternatives with DTFC treatments it represents the lowest number of high EHR ratings, and the lowest overall risk of erosion.

Herbicide applications targeting noxious weed species would create an initial pulse of ground cover as dead vegetation falls to the ground. While some of the noxious weed species provide ground cover for soil stabilization, they can also out-compete a diverse range of native vegetation that may produce better quality ground cover for soil stabilization. Less vegetative cover would be present 1 to 3 years after treatment, but if native species reestablish, the benefits for soil stability would outweigh the temporary reduction in vegetative cover. Manual pulling or grubbing weeds in Alternative 1 is expected to occur in small areas, having minimal effects on soil cover and stability.

Herbicide applications for site preparation and release have similar effects as noxious weed treatments, but on more acres. Leaves and woody material from treated shrubs and competing vegetation would die and fall to the ground within the first few years after treatment (Figure 3.11-1, A). In release treatments, this could occur in a large proportion of a unit. Ground cover is expected to increase initially, for 2 or 3 years after a site preparation treatment. During this time, a unit could receive additional release treatments, up to 3 times over a 5-year span. Release treatments would increase ground cover underneath targeted plants, similar to site preparation spray. Since the objective of release treatments is to control and reduce competition to planted trees, less vegetative cover would occur on a site with multiple release sprays. Overall, ground cover is expected to decrease somewhat between year 2 and year 10 after the initial herbicide treatment, and return to normal levels as planted trees drop needles and vegetation returns to the site. Total ground cover is difficult to predict in herbicide treated units, but in units not having tractor piling or DTFC treatments, it is expected to meet forest standards at all times through the final release treatment. In herbicide units without tractor piling or DTFC treatments, no areas are expected to have high EHR, and a majority of the units would have low EHR, and low expected erosion rates. When used in combination with mechanical site preparation treatments, ground cover conditions are determined by the mechanical methods with likely higher EHR values.

SURFACE AND SOIL ORGANIC MATTER

Surface organic matter refers to organic material on top of the mineral soil surface, including coarse woody debris (CWD), fine wood, and forest floor layers (O soil horizon). This material (especially finer sizes) is important for nutrient cycling and support of soil microorganisms. Soil organic matter (SOM) refers to organic matter that is a component of mineral soil horizons (mainly A horizons). In soils without high clay content, most nutrient exchange occurs in surface soil horizons where SOM is

highest. Because of this, it is important to protect SOM, especially on soils with thin A horizons, such as Lithic Xerumbrepts and other shallow soils listed in Table 3.11-1.

Thinning units would generally have surface organic matter redistributed, but not moved off site. Where trees are felled and skidded, small limbs and needles are likely to break off, causing a moderate increase in fine woody debris. The O horizon would be displaced and mixed in areas where feller bunchers walk and on light skid trails. On heavy skid trails, surface organic matter would be buried and mixed in with surface soil horizons and would be scraped away close to landings. 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. Displacement can also lead to channelized flow from entrainment between berms, reduced infiltration, and reduced surface roughness. Prescribed burning done before thinning would reduce surface organic matter through combustion, but relatively moist fuels in spring or fall burns should prevent large continuous losses of surface organic matter. This combination of activities would likely cause a reduction in, or possibly a neutral effect on, total nutrient pools in the forest floor. Many remaining nutrients, especially nitrogen, would mineralize or be released into mineral soil and would be more available to plants and soil biota (Moghaddas and Stephens 2007; St. John and Rundel 1976). Areas with high soil burn severity would result in a net loss of SOM as a result of combustion and volatilization of nutrients. This higher loss of SOM is more likely under pile burning, where fuels are concentrated and are expected to create enough heat to combust SOM immediately under piles.

Effects of mechanical site preparation done with feller bunchers or grapple piling would have effects similar to those described for thinning treatments. Mastication treatments would cause a direct increase in surface organic material. Masticated material acts as good soil cover, but in the short-term it does not have the same nutrient exchange properties as SOM or forest floor material. In the long-term as masticated material breaks down, it would provide nutrient exchange benefits. Site preparation with tractor piling could remove surface and SOM, as discussed above, via sweeping of topsoil into machine piles. Management requirements would limit the amount of soil that ends up in machine piles, protecting SOM, and the requirement for a brush rake should reduce the amount of surface organic matter that is removed. Depending on pre-piling site condition, soil cover (including surface organic matter) could still be reduced below 40%.

DTFC treatments mix surface soil layers, and can bring rocks or subsoil to the surface, especially in thin soils or those with higher clay content. This has effects similar to soil displacement when subsoil layers are brought to the surface. This displacement would occur unit-wide, except in buffer strips and untreatable areas such as rock outcrops. The forest cultivation treatment is designed to uproot and bring to the surface competing vegetation species, especially bear clover. This treatment would remove some surface organic material by mixing it into deeper soil layers, and would remove subsurface organic material such as roots by bringing them to the surface. When done in combination with tractor piling, large woody debris and fine woody debris would be almost completely removed from a site, with the exception of down log management requirements. Forest monitoring completed in 1993 showed all measured units failed to meet soil quality standards for small and large woody material (Brown 1993). Management requirements retaining a buffer strip for every 100 feet of contour DTFC would mean a minimum of 8% of a unit would not receive DTFC, and should retain sufficient levels of surface and SOM. Outside these areas, surface organic mulch would remain below forest standards in the short-term, at least 2 years, until vegetation and planted trees produce sufficient surface organic material. The effect on SOM in the short-term would mean surface organics would be incorporated into the soil, and would increase organic carbon below ground. This result was shown in monitoring done on a Josephine soil on the Stanislaus where 3 of 4 sampled plots had a decrease in organic carbon at the soil surface (0-6 inches), and an increase of organic carbon in deeper soil layers

(O'Geen 1993). In the long-term (more than 5 years) it is unclear what would happen to SOM following DTFC. Mixing of soil may cause similar effects as soil displacement by exposing less productive subsoil layers, and increasing organic matter decomposition by increasing oxygen presence. Surface organics incorporated deeper into the soil may compensate for this loss somewhat, but overall SOM levels are predicted to decrease in the long-term. Visual inspections of DTFC units from the 1990's consistently display a lack of dark soil colors that are typically associated with high organic matter content in the A horizon, and often show noticeably slow organic matter decomposition at the surface, and little incorporation of new litter into the soil. However, no sampling has been done to show if levels of organic carbon are reduced in the long-term compared to units that did not have DTFC treatment.

Noxious weed eradication treatments would temporarily increase surface organic matter from dead vegetation accumulating on the soil surface, but are not expected to affect SOM levels. Herbicide site preparation treatments would also increase surface organic material in the short-term (Figure 3.11-1, A) as killed vegetation falls to the surface and decomposes. The effect to SOM in the long-term is unclear. Site preparation and release treatments would specifically target species like bear clover and deer brush that have underground root networks that contribute to increases in SOM and fix nitrogen (deer brush). These species would be reduced in herbicide treated areas for at least 5 years over the length of possible release treatments, but the rate they would recover is variable, and the long-term effect on SOM is unknown.

SOIL STRENGTH AND STRUCTURE

Changes in soil porosity can affect water holding capacity, air and water movement, and the ability of roots to penetrate the soil (Alexander and Poff 1985; Williamson and Neilson 2000). A majority of actions are taking place on soils with a high compaction hazard (Table 3.11-1)

Soil compaction by mechanical equipment would reduce total porosity in thinning units. Feller bunchers are considered low ground-pressure equipment and are not expected to cause widespread compaction. Skidding operations, however, would detrimentally compact the soil. Williamson and Neilson (2000) found that most compaction occurs after 3 passes of log-laden equipment. Landings are areas of high compaction because they support skidding equipment, processors, and biomass trucks The reduction of porosity would be greatest on landings and segments of main skid trails; however, compaction monitoring on the Stanislaus National Forest has shown that the footprint of the severely compacted areas is typically less than 15%, which meets the Forest standard (Janicki 2006; Jimenez 2007). Additionally, smaller trees would be removed in existing plantation thinning, creating lower ground pressure and weight of skidding equipment compared to thinning larger trees and fewer passes along each skid trail would be needed.

Hand thinning and prescribed burn activities would have little to no effect on soil porosity or compaction. However, prescribed fire activities could alter soil structure at the surface of the soil. Organic matter can combust in surface layers of the A horizon (top 2-3 cm) if fire resides in one location long enough to heat soil to that depth. This could change the soil structure from granular to single-grain. However, with spring or fall burning and relatively high soil moisture content, this effect should be minimal compared to dry-season wildfires.

Effects of mechanical site preparation done with feller bunchers, mastication, or grapple piling would have effects similar to those described for thinning treatments. Slight reductions in soil porosity may occur, but should not reduce soil productivity. Tractor piling would cause similar levels of compaction when compared to thinning treatments, but the distribution would be different. Instead of compacted skid trails, compacted areas would be concentrated around machine piles where the dozer made multiple passes. However, if any of these thinning or site preparation treatments are followed by DTFC, the effects of compaction would be reduced. Deep tilling loosens soil and is often used as a treatment to alleviate compaction. The 1993 monitoring showed that 88% of DTFC units met the

forest standard for maintaining porosity and preventing compaction (Brown 1993). In coarse-textured soils, DTFC is not expected to drastically alter soil structure that is important for soil hydrologic function, and macroporosity levels would be maintained. In denser clay soils such as Sites and Josephine (Table 3.11-1), DTFC would increase macroporisity in the short term (1 to 3 years) by loosening dense clay subsoil, but after the soil settles, macroporosity may actually be reduced because of the destruction of soil structure, and the reduction in root channels and other large pores in clay soils. This alteration of coarse soil structure may be one of the factors that led to the increased erosion recorded in past monitoring (Schmitt 1997). Infiltration is increased in the short-term because of soil loosening, but after about 3 years the benefits are lost as infiltration rates slow.

Noxious weed eradication and herbicide site preparation or release treatments are not expected to have a noticeable effect on soil strength, porosity, or soil structure because they do not require heavy equipment operation.

SOIL MOISTURE REGIME

Most proposed treatments (thinning, prescribed fire, noxious weed eradication, mechanical site preparation or herbicide site preparation and release) are unlikely to affect soil moisture regime on uplands. Where these treatments occur, soils don't typically have a hydric, or moisture-dependent, soil moisture regime. Thus, these activities are not discussed for this soil indicator in any of the remaining alternatives.

Low density conifer planting around meadow perimeters and removing live trees around meadows would help maintain water-dependent moisture regimes in meadows by reducing water uptake by planted trees in the long-term.

DTFC treatments may alter the surface and subsurface water flow patterns within a unit by changing infiltration rates and water permeability, but the effect this would have on soil moisture regime is unknown. Increased infiltration for up to 3 years could reduce surface flow of water, or at least alter its course across a unit. Many water-dependent moisture regimes are influenced more by ground water than surface water.

FILTERING BUFFERING FUNCTION

The only actions that could affect filtering-buffering function of soil are herbicide applications. The other treatments are not evaluated for this indicator.

Glyphosate is the only herbicide proposed for use in site preparation or in release treatments for the purposes of reforestation. According to the SERA report (2011), there is very little information suggesting glyphosate will be harmful to soil microorganisms under field conditions. Other research indicates that glyphosate can harm soil microorganisms under lab conditions, but it is likely to enhance or have no effect on soil microorganisms in field conditions or in soil (Busse et al. 2001; Wardle and Parkinson 1992). From examination of the effects of glyphosate on microorganisms in numerous forest soils throughout northern California, Busse et al. (2001) failed to detect any changes in microbial population size, diversity, or function due to the herbicide applied at the field rate. When applied at concentrations well above the recommended rate, soil microbial growth was stimulated. Additionally, glyphosate does not appear to reduce the beneficial effect of mycorrhizal fungi (Busse et al. 2001; Chakravarty and Chatarpaul 1990). Ratcliff et al. (2006) concluded that glyphosate has a benign effect on both soil bacterial and fungal community structure when applied at the recommended field rate to organisms in their native soil habitat.

The fate of herbicides in soil is determined by their chemical structure and reactivity or how they interact with the soil environment. Substances that are soluble in water and do not adsorb readily to soil particles or organic matter can be leached through the soil. Such substances have the potential to reach water when precipitation amounts exceed the water infiltration rates of the soil. Substances that are adsorbed (roughly, bonded to) soil particles are mostly degraded in place and resist leaching.

Adsorption of chemicals to soil particles depends primarily on soil clay and organic matter content, temperature, and pH.

Glyphosate tends to readily adsorb to soil particles, and is degraded by microbial action. This gives Glyphosate a relatively low mobility in soil, rarely penetrating below 12 inches depth. Its persistence in soil is typically less than 3 months and can be less depending on the soil conditions (SERA 2011). Past monitoring on the Groveland Ranger District has showed with typical application rates used for site preparation and release, glyphosate was not detected in soil after treatment (Griffith 1993).

Relatively little information is available on the toxicity of clopyralid to soil microorganisms. At concentrations of 10 parts per million (ppm) in soil, clopyralid had no effect on nitrification, nitrogen fixation, or degradation of carbonaceous material (SERA 2004). The USFS uses the 10 ppm value as a no observed effect concentration (NOEC) for soil microorganisms. Use rates for noxious weed eradication would be approximately 0.1 milligram clopyralid per kilogram of soil, which is far below the known value for potentially toxic levels for soil organisms.

Clopyralid is degraded primarily by microbes in soils and aquatic sediments. No metabolites accumulate during the degradation process and therefore, no additional contamination of the environment occurs (Pik et al. 1977). The half-life in soil can range from 10 days to 10 months, depending on soil temperature and moisture conditions (SERA 2004). The half-life for clopyralid is expected to be approximately 25 days for soils in areas treated for noxious weeds. Clopyralid does not bind tightly to soil particles, however the potential for leaching or runoff is functionally reduced by the moderate degradation of clopyralid in soil. Recent monitoring on the Groveland Ranger District showed no evidence of clopyralid entering water after it was sprayed on noxious weeds adjacent to a stream (Peterson 2012a, 2012b).

The half-life of Aminopyralid in a field setting in soil can range from 25 to 74 days. Longer times of persistence (over 300) days have been observed in a laboratory setting where degradation of aminopyralid was the only means of dissipation (SERA 2007a). Soil invertebrates, including earthworms, appear to be relatively unaffected by aminopyralid and show no observable effects when exposed to 5,000 milligrams active ingredient per kilogram of soil (SERA 2007a). Similarly, soil microorganisms do not have adverse effects observed at concentrations up to 8 milligrams per kilogram of soil. In fact, the only observed effect was an increase in nitrate and total mineral nitrogen on the day aminopyralid was applied (SERA 2007a). Because of the application rates for this herbicide are very low, concentrations are expected to be well below the no effect concentrations given for soil microorganisms and invertebrates. Based on the persistence and toxicity information for Aminopyralid, it is not expected to cause any negative effects to soil microorganisms.

There are very little data available about the effect of clethodim on soil microorganisms, or other soil biota. The only terrestrial invertebrate that has toxicity information available is the honey bee, which has a No Observable Adverse Effect Level of 860 milligrams per kilogram of body weight. With normal application rates, it appears clethodim is unlikely to negatively affect bees and aquatic invertebrates (SERA 2014). Clethodim is not readily adsorbed by soil or organic matter particles, so, in a laboratory environment, it has been shown to be moderately mobile in soil. However, its expected half-life in a field environment is the shortest of any herbicide proposed for use in this project at only 3 days. With the proposed application methods and management requirements to limit timing of application there is a low probability that clethodim would be leached out of the soil profile or be moved off site through sediment losses because most of the substance it is likely to break down in a few days.

Cumulative Effects

Units that are proposed for DTFC site preparation would mitigate any compaction that resulted from Rim Recovery salvage logging treatments. This would be a beneficial effect, especially in units that were salvaged logged during the wet season.

There are several scenarios where the combined effect of past actions and currently proposed actions may create cumulative negative effects to the soil resource, or specific soil indicators. Those scenarios are where currently proposed actions overlap with: high soil burn severity from the Rim Fire, dozer piling proposed in the Rim Recovery, and in some cases salvage logging proposed in the Rim Recovery. Tractor piling that was proposed in the Rim Recovery would occur in many units with the same footprint as Rim Reforestation units. The combined effect of tractor piling and thinning, or prescribed burning treatments in Reforestation would reduce ground cover sufficiently to create a high EHR condition. This would create a cumulative negative effect on soil stability and surface organic matter, and 1,260 acres would be moved to a high EHR category.

The combination of prescribed burning and thinning in existing plantations and deer habitat enhancement units is not likely to cause a cumulative negative effect in areas where the Rim Fire burned with low or moderate soil burn severity. However, where high soil burn severity occurred, there may be a cumulative negative effect to surface and soil organic material and total soil nutrient pools. The overlapping area of high burn severity and prescribed burning is smaller than the overlap with Recovery tractor piling which would have a more direct and predictable negative effect on surface and SOM.

Finally, locations with high soil burn severity in the Rim Fire, followed by salvage logging (excluding Watershed Sensitive Areas), followed by mechanical site preparation (especially dozer piling or DTFC) are the most susceptible to negative cumulative effects to soil resources. For EHR analysis, tractor piling treatments proposed in the Rim Recovery were used to determine the existing condition for ground cover, so the cumulative effect of that treatment would be captured. Areas with high soil burn severity that receive tractor piling treatments are the least likely to have sufficient surface organic matter to meet forest plan standards of 50% organic mulch after site preparation. It is expected that most of these areas will not meet forest plan standards after treatment.

Alternative 2 (No Action)

Direct and Indirect Effects

SOIL STABILITY

Under Alternative 2, no project activities would occur, so there would be no direct effects on the soil resource. Other actions described under the Rim Recovery and other projects would continue. Because of the Rim Fire and Rim Recovery project activities, EHRs would be slightly elevated over their natural (unburned) condition, but no areas in the project area would have a high EHR. In most cases, soil cover for erosion protection would be limited to natural rates of accumulation, based on the vegetation types present post-fire. If there are locations that were under a forested vegetation type before the Rim Fire that are now chaparral vegetation, natural levels of ground cover could be reduced below their pre-fire condition. This could contribute to higher rates of erosion in the long-term (greater than 10 years), if forest vegetation is not re-established. This condition would mostly be expected in areas that are currently manzanita or chamise chaparral. Bear clover and other vegetation types that produce nearly 100 % ground cover would have similar erosion rates in the long-term as a forested site.

Noxious weed populations would remain and continue to displace native vegetation. In some cases, such as with non-native annual grasses, this could lead to a long-term reduction in soil stability. Native bunch grasses evolved under the area's historic fire regime, and the soils that formed under

these native species are a product of that long-term relationship. Non-native species may cause a long-term reduction in stability of soil, leading to a reduction in soil productivity.

SURFACE AND SOIL ORGANIC MATTER

The vegetation type and amount of vegetation recovery would determine the levels of surface organic matter that accumulate in the short-term under Alternative 2. Monitoring shows that units receiving dozer piling in the Rim Recovery may have reduced surface organic matter levels for several years until new vegetation restores ground cover and litter layers. In most parts of the project area, vegetation that has become established since the Rim Fire would dominate SOM processes. Soil cover would continually be added by litter accumulation, and nutrient cycling processes would be dominated by natural processes.

In existing plantations, no thinning or removal of standing small trees would occur; this material would fall over the next several years and accumulate fine and coarse woody material on the soil surface. In existing plantations that experienced high vegetation burn severity, fuel loadings in the next 5 to 10 years could reach levels that cause severe soil heating in a fire, if they were to re-burn (Brown et al. 2003). One study, in adjacent Yosemite National Park, examined the effects of multiple fires on vegetation in unlogged areas. Areas of high soil and vegetation burn severity were more likely to burn at high severity again in future fires (van Wagtendonk et al. 2012). However, areas that burned at low or moderate burn severity initially and had maintained forest conditions were more likely to burn at low or moderate burn severity in later fires. Fuel loading in contact with the soil surface is likely the most important variable in determining risk of fire damage to the soil during a possible reburn. Since a large part of the project area would be treated for fuel loadings in other projects, under Alternative 2 only unthinned plantations are at risk of fire damage to the soil.

SOIL STRENGTH AND STRUCTURE

Existing levels of compaction under Alternative 2 would not be altered. Any existing compaction from legacy treatments or from Rim Recovery salvage logging would remain until natural processes restore soil porosity. Conversely, no additional compaction would be created from dozer piling, thinning, or other mechanical site preparation treatments.

SOIL MOISTURE REGIME

Thinning of live conifers around meadows would not occur under Alternative 2. In a few cases where there is conifer encroachment threatening the moisture regime, this could impact the meadow's available water and moisture regime. In a majority of the project area, however, no actions would take place that affect soil moisture regime and existing conditions would continue to determine available water for soils in water-dependent systems.

FILTERING BUFFERING FUNCTION

No herbicide applications would occur under Alternative 2. Soil microorganism populations would continue to cycle under normal post-fire conditions, and there would be no risk of herbicide substances leaching or movement within the project area.

Cumulative Effects

In the short-term, stabilizing vegetation that has grown since the Rim Fire would continue to expand and produce soil cover at natural rates and would not be altered by site preparation actions. Any existing compaction in DTFC areas would remain and slowly recover with natural processes. Erosion hazard would remain at moderate levels or below in all parts of the project area. In the long-term, in areas that transitioned from a forest-dominated to a chaparral-dominated environment, natural ground cover levels could be reduced and annual erosion rates could increase. To have a severe negative effect on soil productivity this vegetation type change and increased erosion rate would have to persist for a long period of time.

Alternative 3

Alternative 3 differs from Alternative 1 where changes affecting soils include: elimination of the use of herbicides, additional amounts of DTFC and hand grubbing. Management requirements affecting DTFC also differ from Alternative 1. Alternative 3 proposes additional DTFC site preparation treatments on 646 acres of proposed deer habitat enhancement areas, and on 3,809 acres of the proposed reforestation treatment areas. The additional areas of DTFC would be on sites that were proposed for herbicide site preparation in Alternative 1. The slope limitation for DTFC would be increased to 35%, and untilled buffer strips on steep slopes (over 20%) or below roads would not be required.

Direct and Indirect Effects

SOIL STABILITY

All thinning and pre-thinning prescribed burning would be the same as described in Alternative 1. Initial site preparation using prescribed burning or mechanical and hand treatments would also be the same as described in Alternative 1. The described effects, and the acres treated would be the same as Alternative 1.

The additional DTFC treatments would increase the risk of erosion on nearly all of the newly proposed acres. The removal of buffer strips and increase of suitable slope for this treatment increases the likelihood of concentrated water flow coming off of a road and initiating rill erosion, and would increase rill energy on slopes above 30%. Soil properties in each additional DTFC unit were reviewed by the soil scientist before being proposed for this treatment. In most of the additional units there are portions within them that had thin soils, steep slopes, or rock outcrops that would not be desirable to subsoil. Additionally, when units met criteria for slope steepness and rock content, some areas were proposed for DTFC on soil types that were said to be unfavorable for this treatment in past monitoring (Schmitt 1997). This increases the risk of erosion compared to DTFC units in Alternative 1. As mentioned under Alternative 1, DTFC would increase macroporosity (and possibly infiltration) on dense clay soils in the short-term. With low intensity rainfall, this effect may prevent rill erosion from initiating in large areas in DTFC treatments, but in the event of large rainstorms with high intensity rainfall that exceeds infiltration rates, resulting in surface flow of water, the risk of rill or gully erosion rates goes up. The likelihood of large, intense rain events cannot be predicted, so there is not a guarantee of more erosion with additional DTFC acres, it simply increases the risk in the event of a large storm. The analysis predicts Alternative 3 would have the most number of units (170) and 22% of the total treated area with a high EHR. This is an increase of 54 additional units and 8% over Alternative 1.

In lieu of site preparation applications of herbicides, manual grubbing would be used after planting to remove competing vegetation. DTFC units would also receive hand grubbing as a release treatment. This action would remove soil cover and expose bare soil around planted trees (Figure 3.11-1, B). The area of a unit affected by grubbing would vary with the number of planted trees, and could range from approximately 45% to 89%. Compared to the herbicide site preparation in Alternative 1, manual grubbing would result in lower ground cover and a slightly elevated risk of erosion in the short-term. Areas between planted trees would not be grubbed, leaving ground cover intact over the remainder of the unit. The additional grubbing has partly contributed to the increased acres of high EHR, but sprouting vegetation is expected to recover much more quickly than Alternative 1 in units that receive herbicide site preparation and release treatments. Thus, in hand grubbed areas the long-term effect of erosion could be increased or decreased compared to Alternative 1, and would be dependent on ground cover levels after the final release treatment is complete.

Noxious weed eradication would be done with one or more of the following methods: grubbing, hand pulling, prescribed fire, grazing, and seeding with native species. Seeding with native species would

increase ground cover and soil stability, a beneficial effect, as native plants are established. All other manual methods would reduce ground cover in some way. The Jawbone Lava Flat area contains the largest contiguous patch of noxious weeds and would have the most area that could have reduced ground cover. After treatment, the EHR within this unit would mostly be moderate, with some areas classified as low.

Although assumptions are factored into all modeling, the increased erosion risk and EHR is substantial enough to conclude that Alternative 3 would have the highest risk of reducing soil productivity as a result of erosion.

SURFACE AND SOIL ORGANIC MATTER

All thinning and pre-thinning prescribed burning would have the same effects as described in Alternative 1. Initial site preparation using prescribed burning, mechanical and hand equipment would also be the same as described in Alternative 1. The described effects, and the acres treated would be the same in Alternative 3 as in Alternative 1.

The additional DTFC treatments in Alternative 3 would have similar effects to surface and soil organic material as described in Alternative 1. Over the additional areas treated with DTFC, surface organic mulch would be reduced below forest standards in the short-term, subsurface organic carbon levels would slightly increase in the short-term and overall SOM levels are likely to decline in the long-term.

By not implementing buffer strips in Alternative 3, the amount of surface organic mulch would decrease further when compared to Alternative 1. In most DTFC units, small untreated areas, such as rock outcrops, would likely remain, leaving surface organic matter intact; however, no minimum amount of surface organic mulch is guaranteed to remain as refugia for normal nutrient cycling processes of forest floor layers. Displacement of SOM, as described in Alternative 1, would occur on the additional DTFC treated areas.

Alternative 3 manual noxious weed eradication treatments would reduce surface organic matter levels below what is described in Alternative 1, but the treatments are not expected to affect SOM levels. Similarly, hand grubbing for vegetation control after planting would displace and reduce surface organic mulch and SOM around planted trees. This would reduce the quality and quantity of organic mulch around trees until vegetation recovers and the trees grow large enough to produce litter. Shrub species such as bear clover and deer brush are expected to recover more quickly than in Alternative 1, but the effect this would have on SOM levels is unknown. In areas without sprouting vegetation, grubbed sites would have reduced SOM levels compared to herbicide release units in Alternative 1.

SOIL STRENGTH AND STRUCTURE

The effects to soil strength and structure in the Alternative 3 DTFC treatments would be the same as described in Alternative 1, but the effects would occur over larger areas. DTFC treatments would reduce compaction, where it exists, on the additional areas and buffer strips as stated in Alternative 1. Soil structure changes would be the same as described in Alternative 1.

SOIL MOISTURE REGIME

The meadow prescriptions and effects to soil moisture regime in meadows for Alternative 3 are the same as in Alternative 1. Alternative 3 includes a management requirement to avoid specific areas within the project that may be dependent on delivery of surface water to maintain soil moisture regime. As discussed for Alternative 1, the overall effect of DTFC on soil moisture regime is unknown, but avoiding areas with plants that are sensitive to changes in soil moisture would maintain the existing condition for water flow, and could potentially preserve the desired soil moisture conditions.

FILTERING BUFFERING FUNCTION

No herbicide applications are proposed in Alternative 3, so the effects to soil filtering buffering function would be the same as described in Alternative 2 (no action). Soil microorganism populations would continue to cycle under normal post-fire conditions without the risk of herbicide substances leaching or moving within the project area.

Cumulative Effects

The additional area of DTFC treatments would create more area at risk of negative cumulative effects to surface organic matter and soil stability, and the effects would be the same as described in Alternative 1.

Similar to the cumulative effects described for DTFC, hand grubbing could create a cumulative negative effect to surface organic matter where it overlaps with Rim Fire high soil burn severity and Rim Recovery salvage logged areas. The combination of these past actions and hand grubbing, especially at the highest tree planting densities, could create a long-term deficit of surface organic mulch that would affect nutrient cycling around planted trees. A cumulative effect is less likely where high surface organic mulch cover or sprouting vegetation exists.

Other cumulative effects, outside of DTFC and hand-grubbed areas would be the same as described under Alternative 1.

Alternative 4

The changes in Alternative 4 affecting soils, when compared to Alternative 1, include: eliminate DTFC treatments, reduce the number of reforestation units and acres of site preparation and release treatments, eliminate herbicide use for noxious weed treatments and add prescribed fire treatments.

All thinning in deer habitat enhancement and existing plantations would have the same acres and effects for all soil indicators as described in Alternative 1. Noxious weed treatment acres and soil indicator effects would be the same as described in Alternative 3.

Direct and Indirect Effects

SOIL STABILITY

Alternative 4 site preparation actions would occur over far fewer acres than in Alternative 1; no more than 20% of a unit area in Alternative 4 would receive mechanical or herbicide treatments. This means a larger area within reforestation unit boundaries would maintain existing soil cover for erosion protection. Where site preparation treatments do occur, they would be similar to those described for Alternative 1, but over fewer acres. Prescribed fire would occur in 50% of the reforestation areas and 50% of the complex early seral forest within the first 10 years. For EHR analysis, it was assumed that the whole unit footprint would receive prescribed fire, because the portions that would be burned are unknown at this time. Even with this over-assumption of treatment area, EHR ratings are reduced compared to Alternative 1. Approximately 2% of the area in Alternative 4, or portions of 12 units, would be elevated to a high EHR. This is a reduction in EHR rating compared to Alternative 1, but EHR levels would still be elevated above the existing condition.

SURFACE AND SOIL ORGANIC MATTER

The reduced area of dozer piling for site preparation treatments in Alternative 4 would ensure surface organic material remains intact over larger proportions of each unit treated, and compared to alternatives with DTFC treatments, surface organic mulch cover would be much higher. This means a larger area would have surface organic mulch available for nutrient cycling. The prescribed burning in reforested areas of Alternative 4 would have effects similar to those described in Alternative 1. Most complex early seral prescribed burning would occur outside the Alternative 1 treatment area, where surface fuel conditions could differ from most of the prescribed burn areas in Alternative 1.

The location and timing of complex early seral prescribed fire is not well defined, so there is uncertainty about the level of effects to surface and SOM. Standing dead vegetation would fall at varying rates over the proposed timeline for prescribed burning, which would change surface fuel loading and how fire affects surface and SOM. However, all prescribed burning would need to retain more than 50% surface organic mulch cover to meet soil management requirements. Overall, surface organic mulch cover is expected to be sufficient in more areas, and SOM would be displaced over a smaller area compared to Alternative 1. In mechanical site preparation areas, improvements in these indicators would be proportional to the difference in acres treated between Alternative 1 and Alternative 4.

SOIL STRENGTH AND STRUCTURE

The nature of effects from mechanical site preparation and prescribed burning in Alternative 4 would be the same as described for Alternative 1, but would occur over a different area. The effects of mechanical site preparation would occur over a smaller area, and prescribed burning would occur outside unit boundaries described in Alternative 1. A major difference would be that DTFC treatments would not occur, so there would be no mitigation of compaction where it is created by thinning or site preparation activities.

SOIL MOISTURE REGIME

The Alternative 4 prescription for thinning of existing plantations around meadows is the same as in Alternative 1, so effects to soil moisture regime would be the same as Alternative 1. There is no specific planting prescription for meadows in Alternative 4, but the overall area planted is much smaller than in Alternative 1. Planting areas could be selected anywhere within the footprint of units; as long as planting does not occur next to meadows, then the effects to soil moisture regime in planted areas would also be the same as described in Alternative 1.

FILTERING BUFFERING FUNCTION

Glyphosate is the only herbicide proposed for use in Alternative 4, as no herbicides are proposed to treat noxious weeds. Where it is applied, glyphosate, used only for reforestation treatments, would have similar effects to soil microorganisms as described in Alternative 1. A low risk of off-site movement or leaching of glyphosate could occur, as similarly described in Alternative 1, but the potential affected area would be smaller.

Cumulative Effects

The reduced area of site preparation treatments would reduce the area of negative cumulative soil effects to surface and SOM and to soil stability in Alternative 4. The reduced area of cumulative effects is partly captured in the EHR analysis because Rim Recovery tractor piling was considered when assigning ground cover values. Only 12 units showed high EHR values, a large reduction compared to Alternative 1. Areas of overlap with Rim Fire high soil burn severity are not directly captured in the EHR analysis, but again, the area of overlap between these areas and Alternative 4 treatments would be smaller than in Alternative 1, leading to less area with potential cumulative negative soil effects.

Alternative 5

The changes in Alternative 5 affecting soils, when compared to Alternative 1, include: thin new plantations (replacing post-planting prescribed fire with tree thinning) and increase the slope limit for DTFC to 35%.

Alternative 5 replaces the natural regeneration treatments found in Alternative 1 with reforestation treatments. In Alternative 1, natural regeneration treatments would be monitored first, before implementing reforestation actions, so there is no guarantee reforestation actions would take place if they are not needed. However, in the effects analysis for Alternative 1, all natural regeneration units

were assumed to receive all proposed reforestation actions, to analyze for the most potential impacts. In reality, the total treated area in Alternative 1 could be smaller than Alternative 5, even though the effects described are very similar. In short, Alternative 5 would have the largest "guaranteed" footprint of proposed activities.

Direct and Indirect Effects

SOIL STABILITY

The proposed hand thinning after planting in Alternative 5 would, by itself, have little or no impact to soil cover and stability; however, burning the piled cut material would reduce ground cover underneath the piles and the effects would be similar to those described for pile burning in Alternative 1.If the material is lopped and scattered instead, it would provide additional ground cover for erosion protection.

The increased slope limit for DTFC treatments would lead to slightly more acres within a unit being treated; small pieces of a unit that would have been excluded from DTFC treatment in Alternative 1 would be treated in Alternative 5. This would slightly increase the risk of rill and gully erosion over the whole unit. If rill erosion initiates, it would have slightly more erosive power on slopes above 30%. The EHR tool is a relatively coarse model, and does not capture this small difference in proposed treatments. Thus, EHRs are the same in both Alternative 1 and Alternative 5 with 116 units and 14% of the treated area in a High EHR.

SURFACE AND SOIL ORGANIC MATTER

The additional area treated with DTFC in Alternative 5 would remove surface organic mulch causing a slight reduction in overall mulch cover in each treated unit with steeper slopes. All DTFC units are expected to be deficient in surface organic mulch. So, while the larger area of removal is a negative effect, it would not change the overall unit rating. SOM would be affected by displacement in the same area.

SOIL STRENGTH AND STRUCTURE

Thinning new plantations in Alternative 5 would only be done by hand, so no additional compaction is expected when compared to Alternative 1. The additional pile burning would affect soil structure underneath piles as described in Alternative 1. The additional loss of soil structure under burned piles would be of relatively small extent, because only small trees (less than 10 years old) would be burned. If the material is lopped and scattered instead, it would not negatively affect soil structure. Compared to Alternative 1, no additional negative effects to soil hydrologic function are expected from this treatment.

SOIL MOISTURE REGIME

The application of a 25-foot buffer around all meadows adjacent to reforestation units in Alternative 5 and thinning new plantations to have minimal tree structure adjacent to meadows may lead to slightly higher tree densities around meadows than Alternative 1, but the intent is similar. In the long-term, this would help maintain water-dependent moisture regimes in meadows by reducing water uptake by planted trees, similar to Alternative 1.

FILTERING BUFFERING FUNCTION

With the stated assumption that natural regeneration units in Alternative 1 would be analyzed for all reforestation activities, then Alternative 5 has the same proposed herbicide use, and the same effects to soil filtering buffering function as Alternative 1. The "guaranteed" area impacted by herbicide treatments would be larger in Alternative 5, but the description of effects would be the same as in Alternative 1.

Cumulative Effects

Same as Alternative 1.

Summary of Effects Analysis across All Alternatives

Table 3.11-3 provides a summary of the EHRs across all alternatives, a quantitative prediction of soil stability after treatment for each alternative. The effects on other soil indicators are qualitative summarizations of the previous effects analysis.

SOIL STABILITY

Alternative 3 creates the highest risk of soil erosion, and reduces ground cover below forest standards over the largest area, because of additional DTFC units, large areas of hand grubbing and fewer soil management requirements. Alternative 5 has a slightly elevated risk of erosion over Alternative 1, but less than Alternative 3. Alternative 4 would leave the most soil cover overall in the project area, but treated areas would have the same level of erosion risk as Alternative 1, and erosion risk with Alternative 4 is higher than the no action alternative, Alternative 2.

SURFACE AND SOIL ORGANIC MATTER

Alternative 3 creates the largest area with surface organic mulch below forest standards, due to additional DTFC units and hand grubbing. Alternative 4 would leave the highest percent surface organic mulch on soil surfaces, and would have the lowest impact to SOM. Alternative 5 would have slightly less surface organic mulch than Alternative 1 in added DTFC areas, but more mulch cover elsewhere because of the removal of post-planting prescribed fire.

SOIL STRENGTH AND STRUCTURE

Alternative 3 would have the largest benefit to soil strength by reducing compaction in added DTFC units. Levels of compaction would be similar between Alternatives 1 and 5. Alternative 4 would have the most legacy compaction persisting because of a lack of DTFC treatments; however, it would also create the least amount of compaction because of the smallest mechanical treatment footprint.

Alternative 3 would alter soil structure over the largest area, but severity of effects on soil structure are mixed, with improvement in the short-term, but a loss in structure and reduced infiltration after year 3 over the largest area.

SOIL MOISTURE REGIME

Effects between all action alternatives are relatively similar, and would provide a slight improvement in soil moisture regime in meadows that are water-dependent.

FILTERING BUFFERING FUNCTION

Alternative 3 would have the lowest probability for off-site movement of herbicides, with no leaching of herbicide substances, and effects to soil microorganisms closest to the no action alternative. Alternative 4 has the lowest probability of off-site movement or leaching of herbicides due to glyphosate's high adsorption and relatively low mobility in soil. Alternatives 1 and 5 would have the same risk of off-site movement and leaching, due to the inclusion of more soil-mobile herbicides. All alternatives with herbicide treatments would have similar effects to soil microorganisms; evidence suggests none of the herbicides proposed would have strong negative impacts to soil organisms.

Table 2.03-1 Summary by Alternative of Erosion Hazard Rating

Indicators[1]	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
High EHR	14%	0%	22%	2%	14%
Moderate EHR	70%	59%	63%	89%	70%
Low EHR	16%	41%	15%	9%	16%
Total number of units with area exceeding high EHR	116	0	170	12	116

[1] Percent of alternative area

Table 2.03-2 Summary of soil indicators by alternative

Indicators	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Soil Stability	Increased short-term erosion risk. High EHR in 14% of treated areas.	Lowest short-term erosion risk. Low to Moderate EHR only.	Highest short-term erosion risk. High EHR in 22% of treated areas.	Similar to 2, but slightly higher erosion risk. High EHR in 2% of treated areas.	Similar to 1, but slightly higher erosion risk.
Surface and SOM	Reduced surface organic matter, some below forest standards in the short term. Short-term increase and possible long-term decrease in SOM.	None	Most reduction in surface organic matter, and most area below forest standards in the short term. SOM similar to Alternative 1.	Similar to 1, but least reduction in surface organic matter (best cover) and least impact to SOM.	Similar to 1, but more surface organic matter.
Soil Strength and Structure	Compaction reduction in DTFC treatments Some increased compaction in thinning	Existing compaction levels persist	Most compaction reduction	No reduction of historic compaction, but least area of new compaction	Same as Alternative 1
Soil Moisture Regime	Slight improvement of soil moisture regime in meadows.	No improvement in soil moisture regime	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Filtering Buffering Function	Minimal affect to soil microorganisms from herbicides low risk of off-site movement of herbicides	No affect to soil microorganisms from herbicides no risk of off-site movement	Same as Alternative 2	Microorganism effect same as Alternative 1 Risk of off-site movement lower than Alternative 1 or 5	Same as Alternative 1

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Appendix A – Maps

The following set of maps show the location of deep till and forest cultivation (DTFC) units that were selected for sampling of soil depth and other properties. Descriptions of the field sampling and modeling methods used to create these maps are located below. The Site Observations section (2.01) in the Soils Resource report outlines other data collected.

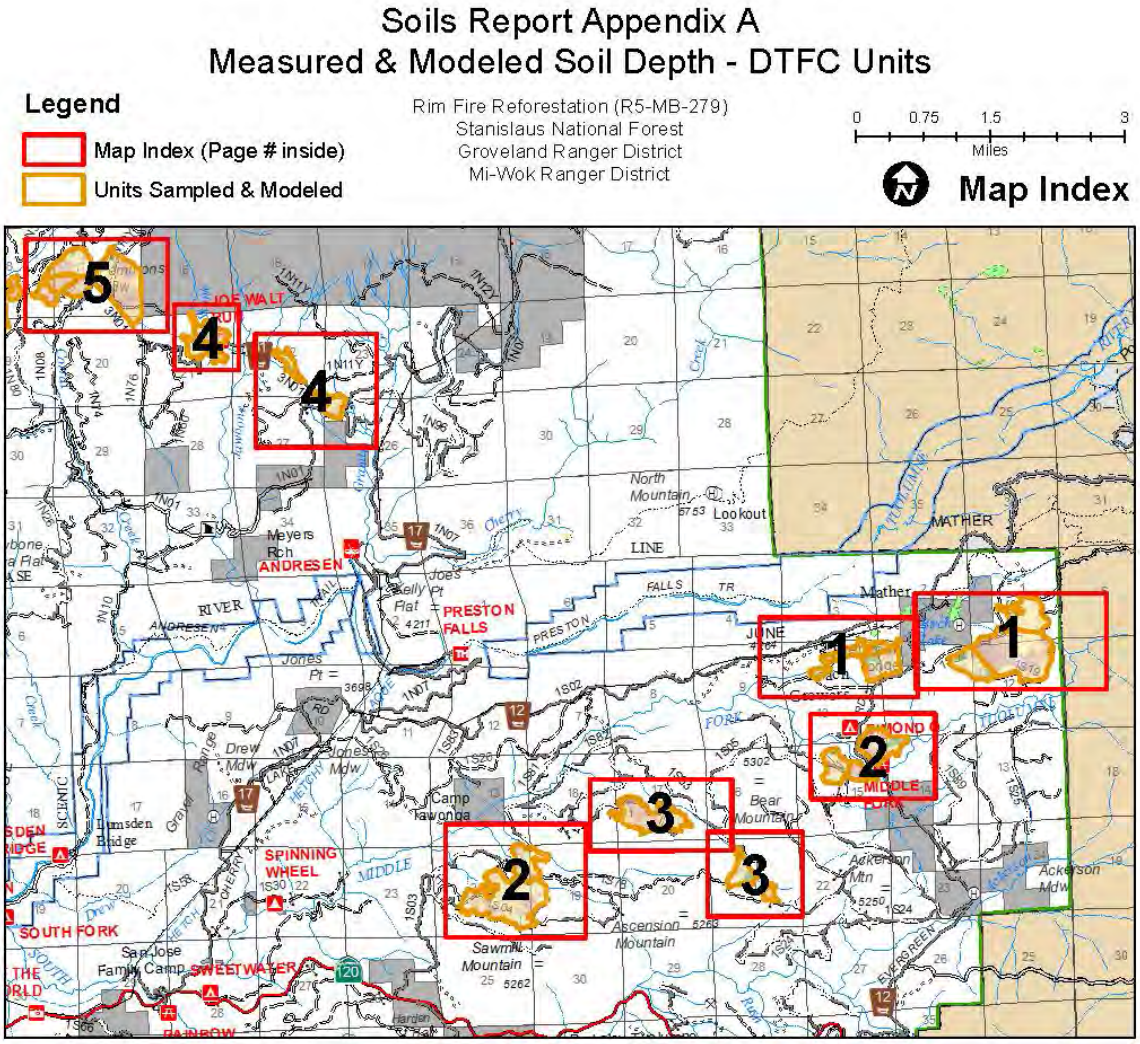
MEASURED SOIL DEPTH-

Soil depth was measured at more than 250 locations within 25 DTFC units. Field crews traversed these units with non-random transects that were selected to evenly cover an entire unit. Sampling points were evenly spaced along these transects when soil conditions appeared uniform. At each sampling point, 2 or more shovel holes and 2 or more auger holes were dug, and the depth of each was recorded along with photos and other site characters. If a parent material or soil depth change was noted visually, additional sampling points (with 2 or more shovel and 2 or more auger holes) were added to the transect. The objective was to measure the full range of variation in soil depth within a sampled DTFC unit.

MODELED SOIL DEPTH-

A raster interpolation method was used to create the modeled soil depths displayed in the following maps. The Spline, two-dimensional minimum curvature technique in ArcMap 10.1 was used to create a modeled surface that predicts soil depth between sampled locations. The spline method forces the modeled surface to pass exactly through the input points, which were the auger & shovel depth measurements. This creates a map with a “best guess” at the soil depth at all locations within treatment units. Rock outcrops & shallow soil areas are displayed in white or brown colors, and deeper soils are displayed in green & yellow.

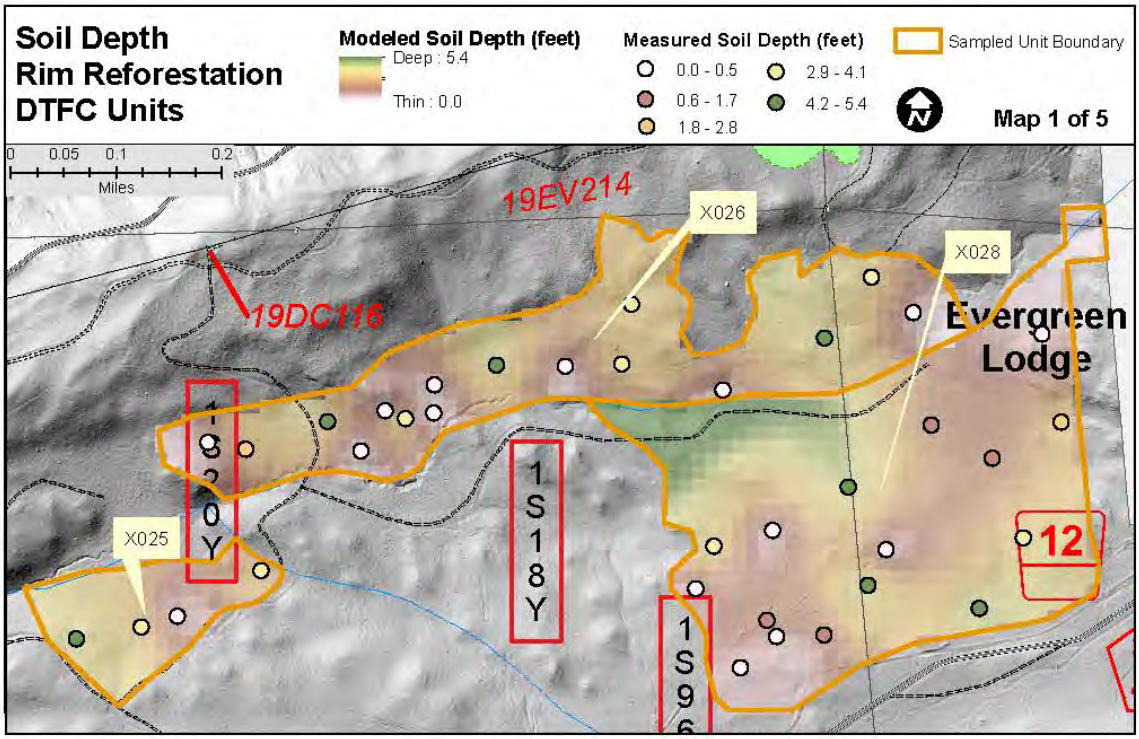
Appendix A Map 1.1 – Index to maps of measured & modeled soil depth

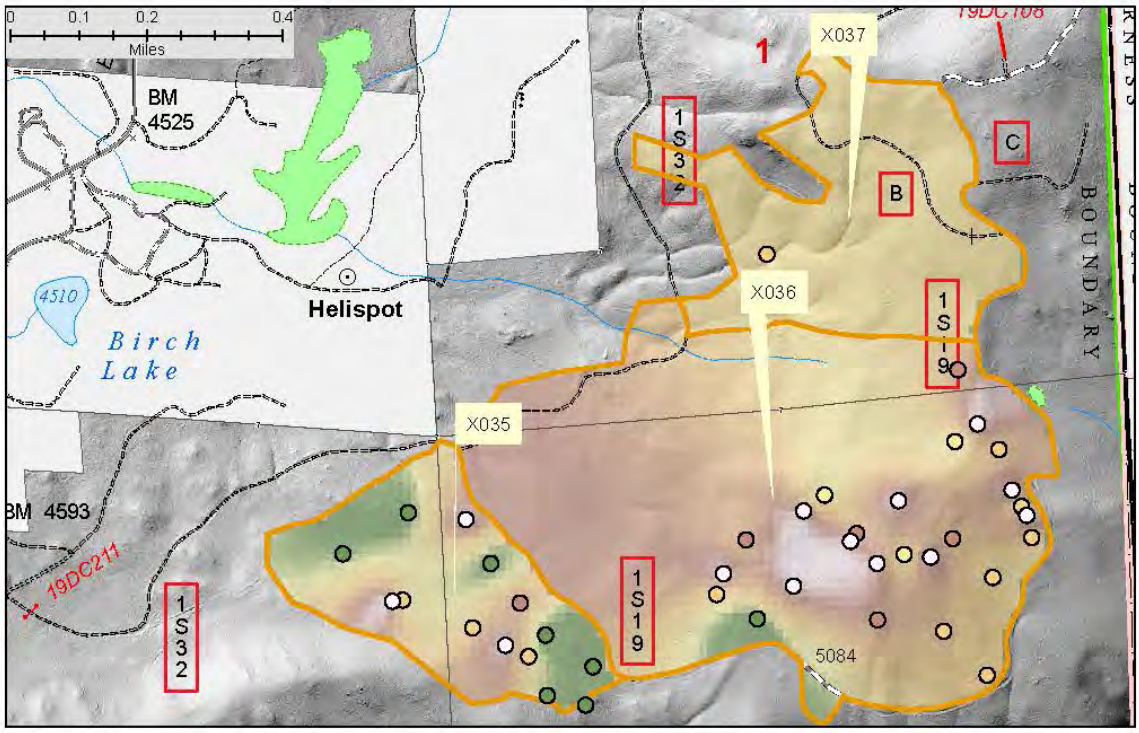


Description

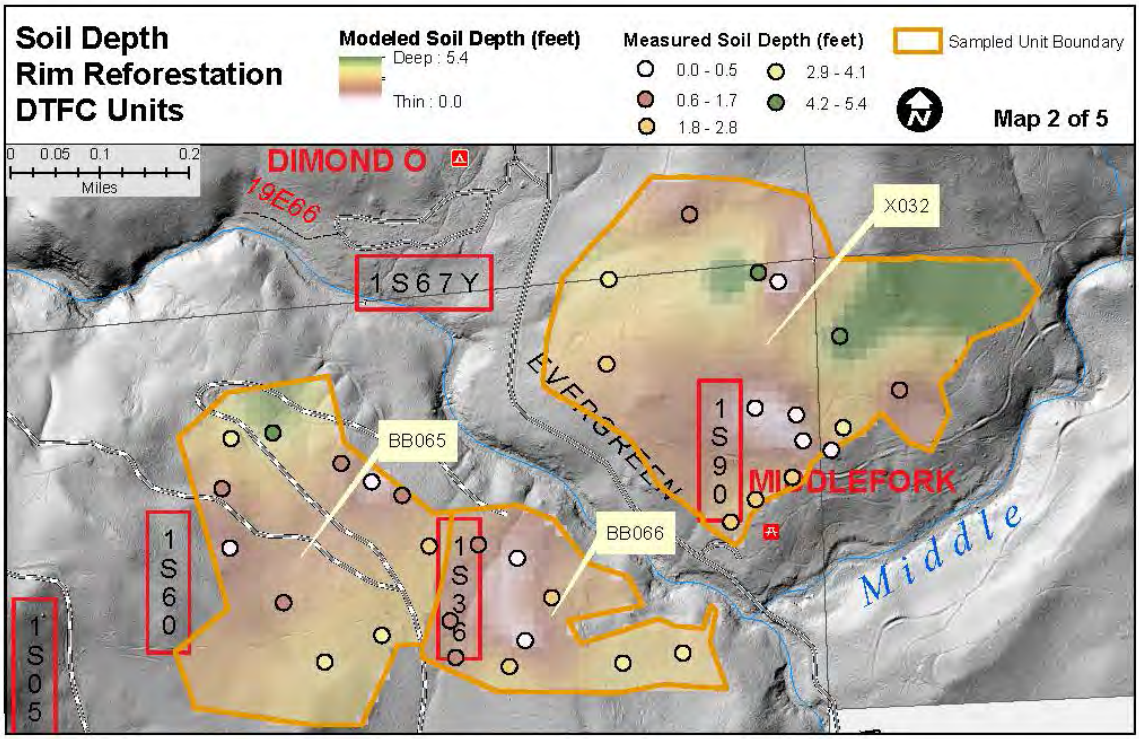
This overview map index page shows the location of Deep Till and Forest Cultivation (DTFC) units that were selected for sampling of soil depth and other properties. Descriptions of the field sampling and modeling methods are located in the Rim Reforestation Soils Resource Report, Appendix A.The Site Observations section in the Soils Resource report outlines other data collected.

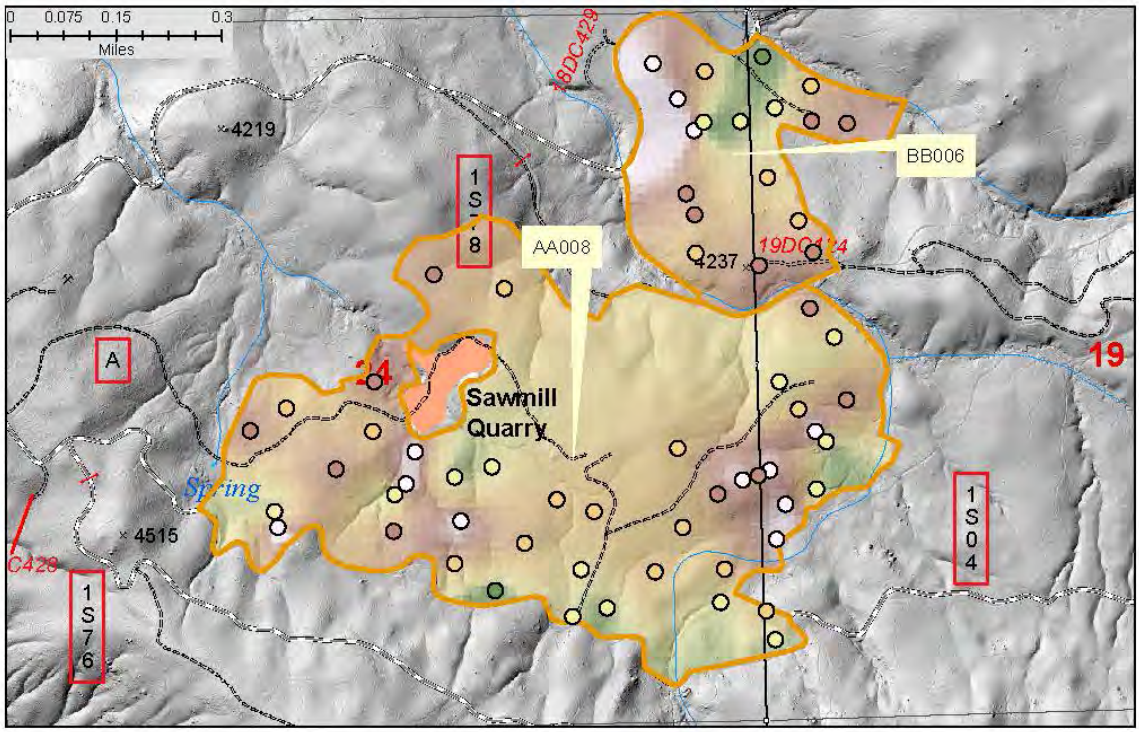
Appendix A Map 1.2 - Modeled soil depth from measured auger & shovel hole points (1 of 5)



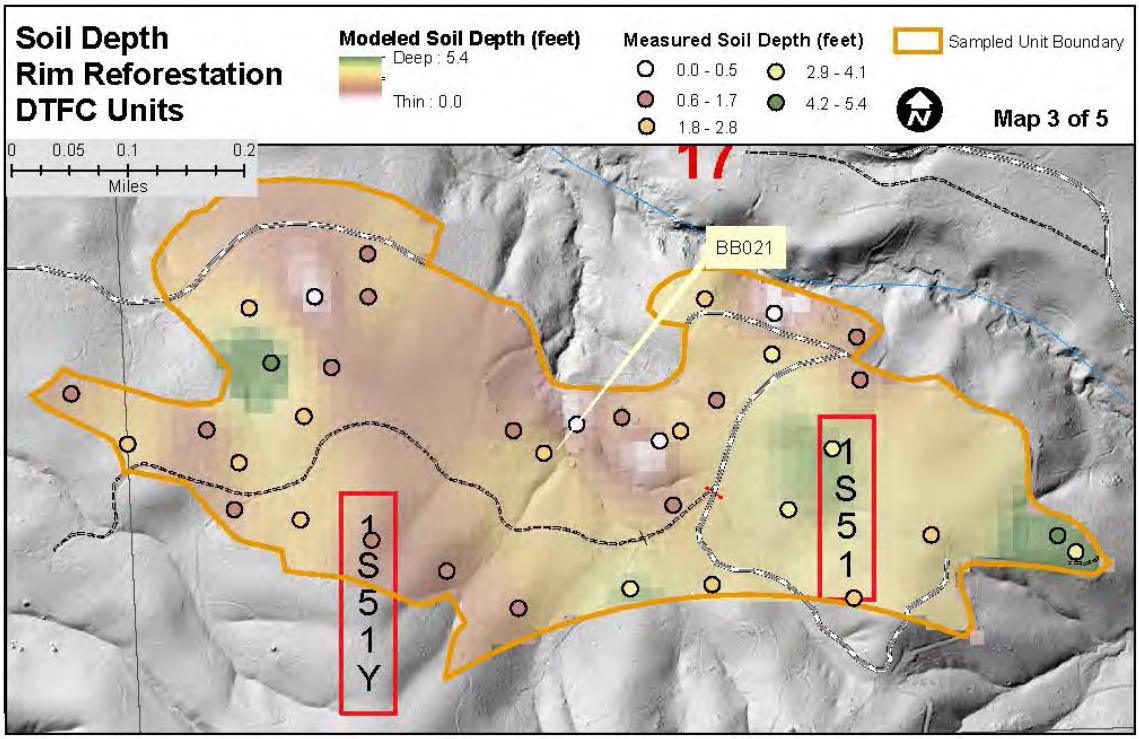


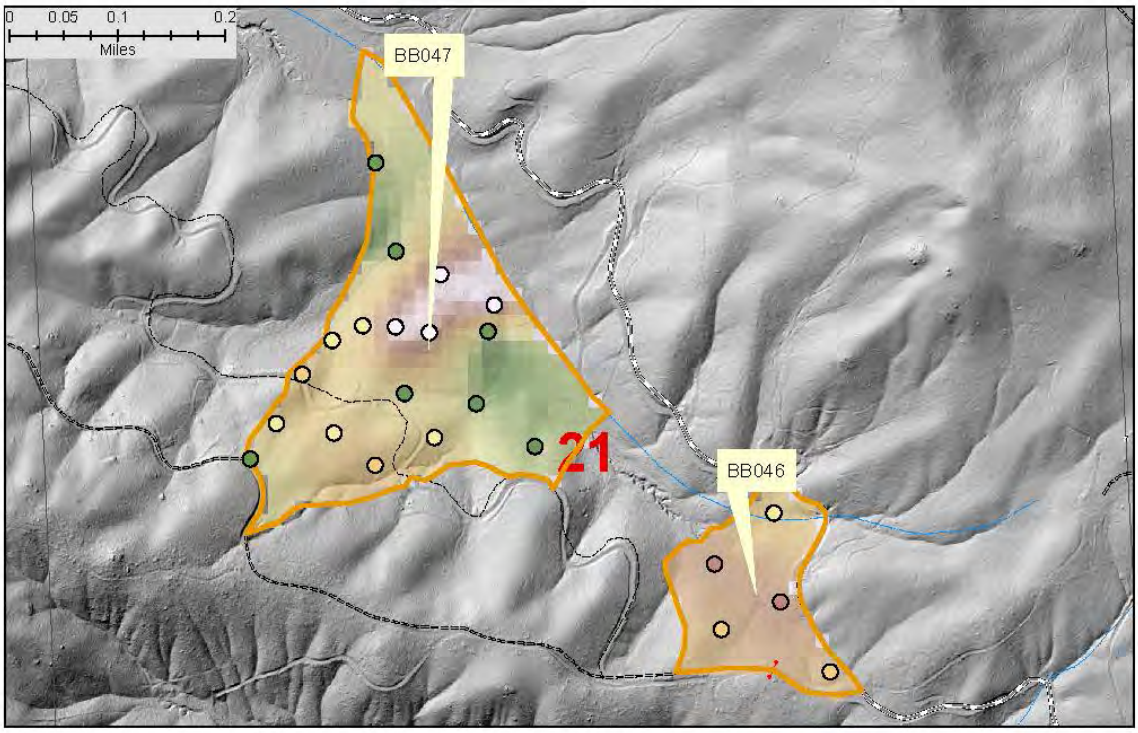
Appendix A Map 1.3 - Modeled soil depth from measured auger & shovel hole points (2 of 5)



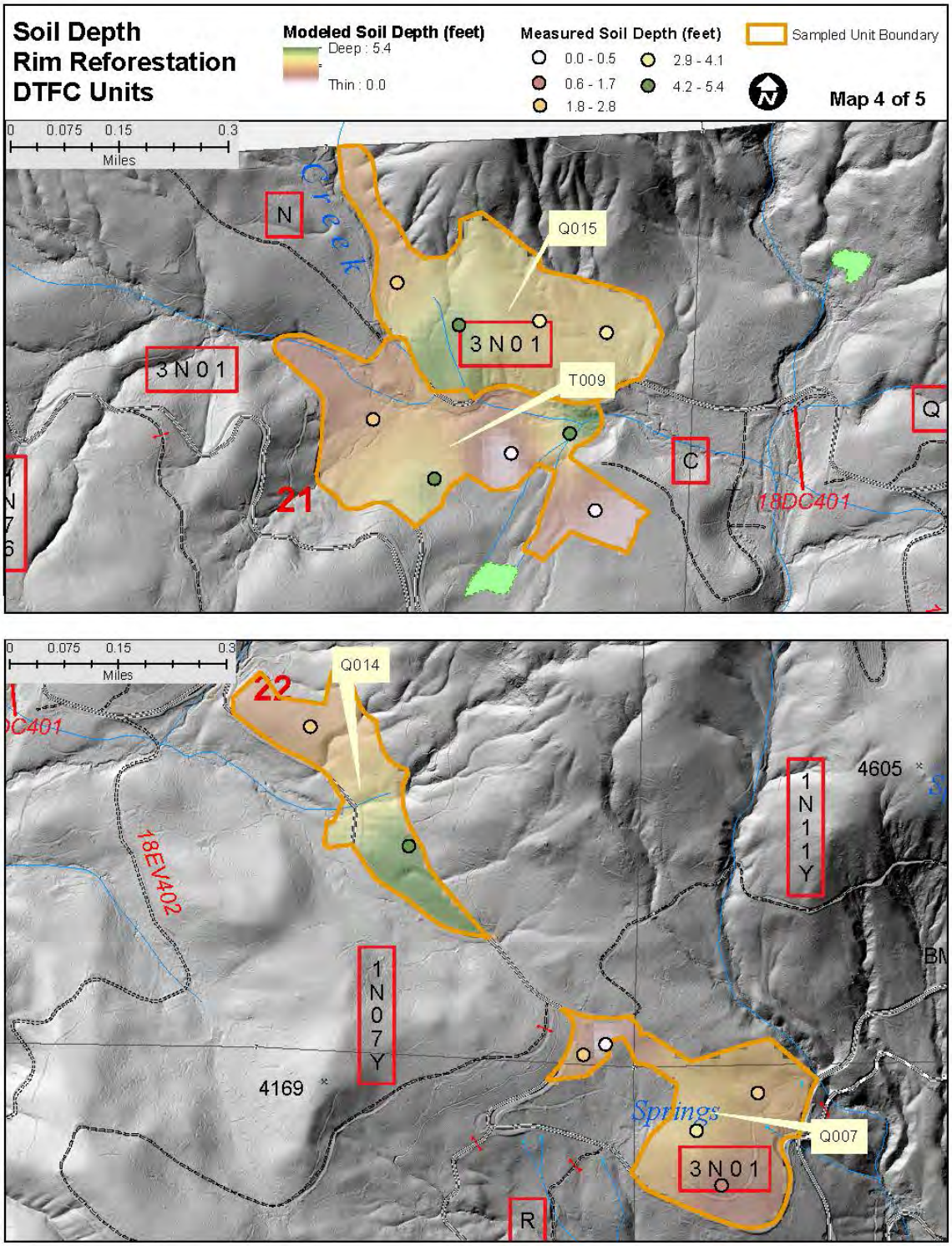


Appendix A Map 1.4 - Modeled soil depth from measured auger & shovel hole points (3 of 5)

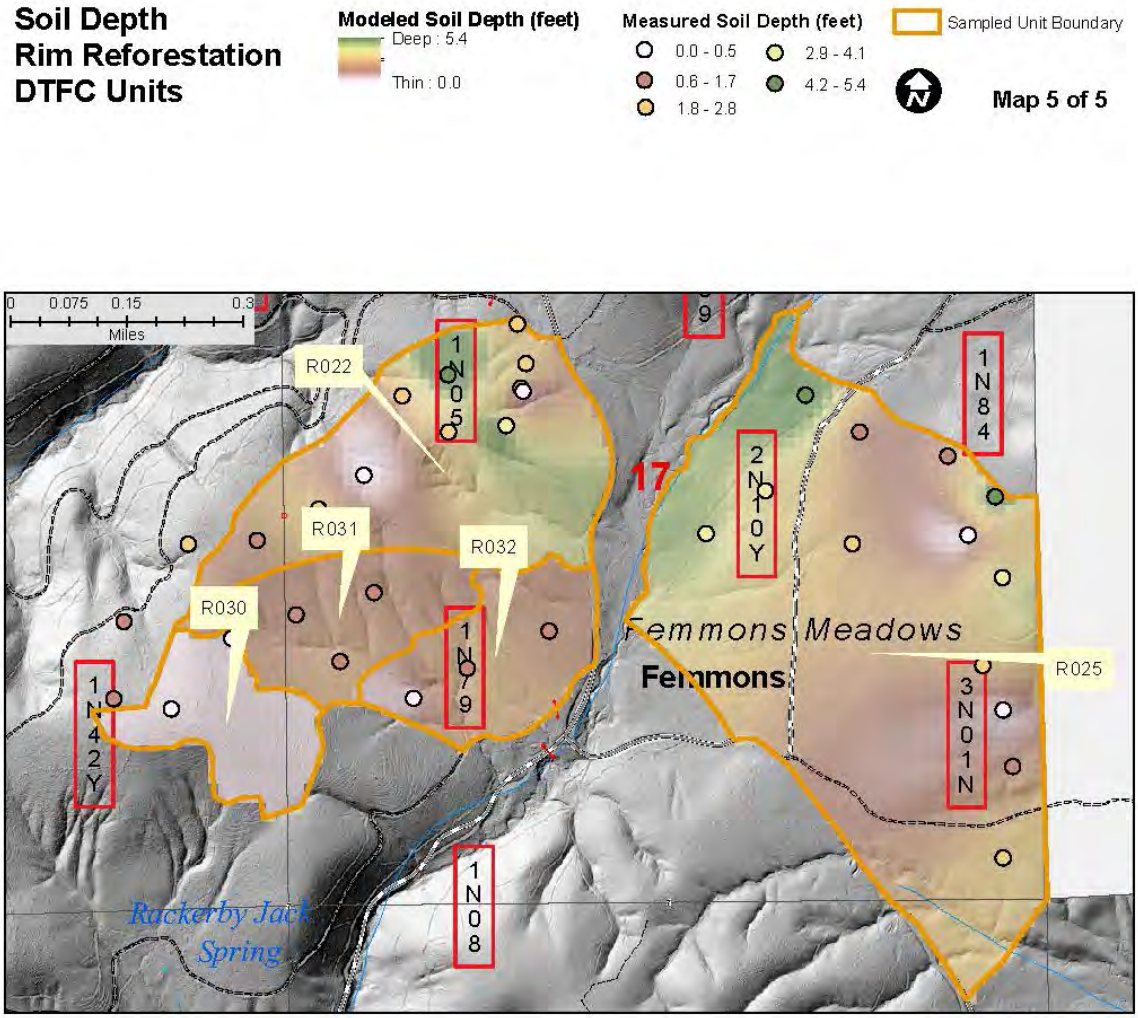




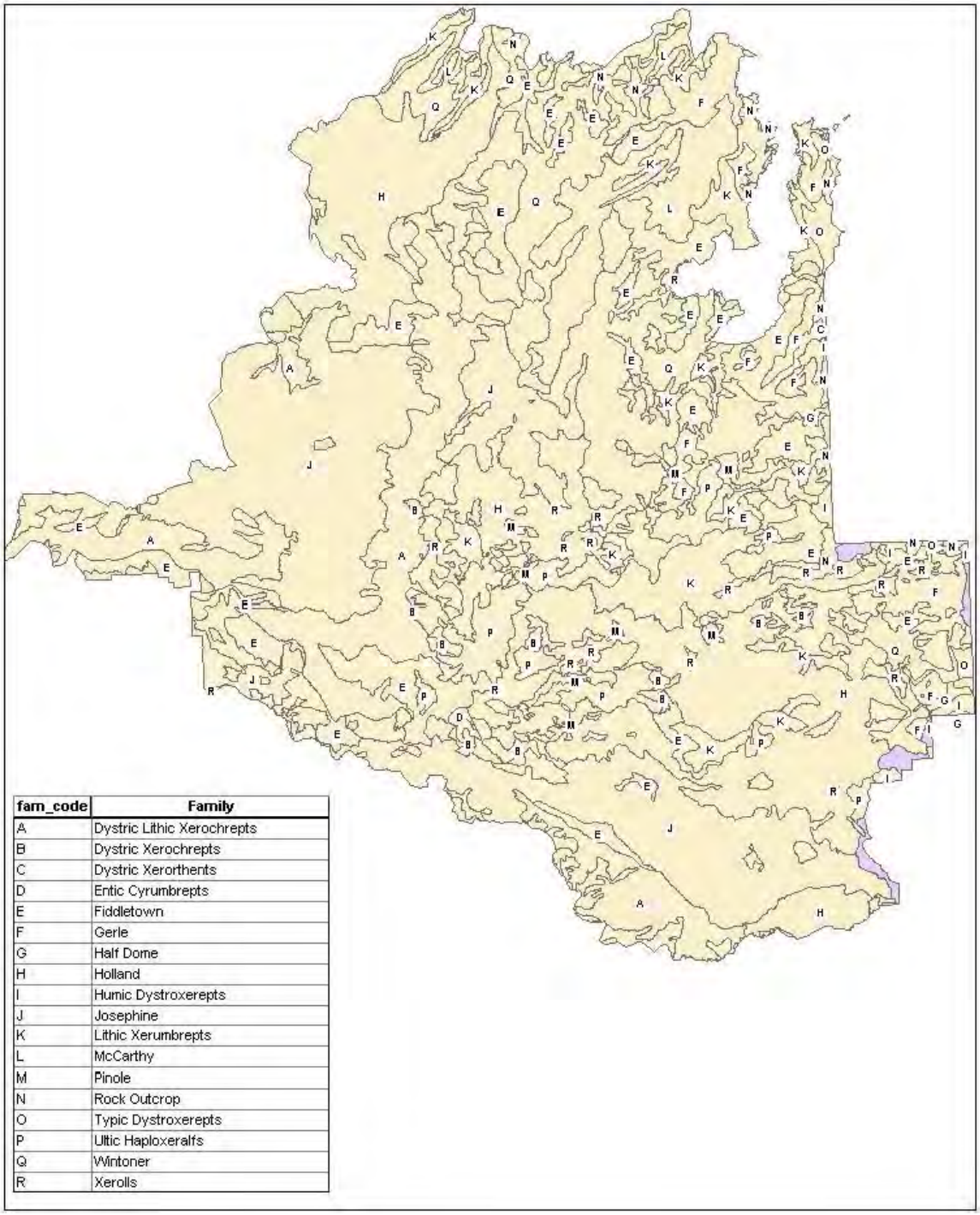
Appendix A Map 1.5 - Modeled soil depth from measured auger & shovel hole points (4 of 5)



Appendix A Map 1.6 - Modeled soil depth from measured auger & shovel hole points (5 of 5)



Appendix A Map 2- 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 – Erosion Hazard Rating

Appendix B Table 1- Units that exceed moderate EHR in greater than 15% of the unit area (high EHR)

Alternative 1			Alternative 3				Alternative 4			Alternative 5		
AA001	AA008	AA010	AA001	AA004	AA008	AA010	AA002	AA009	AA01A	AA001	AA008	AA010
BB006	BB009	BB011	AA012	BB006	BB008	BB009	DD05A	GG12A	GG58B	BB006	BB009	BB011
BB014	BB015	BB016	BB011	BB014	BB015	BB016	HH45B	I065B	I089A	BB014	BB015	BB016
BB021	BB029	BB047	BB021	BB026	BB029	BB033	K018B	R007A	X013A	BB021	BB029	BB047
BB062	BB065	BB066	BB035	BB036	BB047	BB062				BB062	BB065	BB066
BB073	BB075	BB080	BB065	BB066	BB073	BB075				BB073	BB075	BB080
DD003	DD005	DD018	BB080	D014	DD003	DD005				DD003	DD005	DD018
E012	FF001	FF008	DD018	E002	E012	FF001				E012	FF001	FF008
G015	GG001	GG002	FF007	FF008	G015	GG001				G015	GG001	GG002
GG004	GG007	GG010	GG002	GG004	GG007	GG010				GG004	GG007	GG010
GG013	GG015	GG023	GG013	GG015	GG023	GG024				GG013	GG015	GG023
GG024	GG025	GG031	GG025	GG031	GG032	GG033				GG024	GG025	GG031
GG032	GG033	GG035	GG035	GG058	HH001	HH003				GG032	GG033	GG035
GG058	HH006	HH009	HH006	HH009	HH011	HH013				GG058	HH006	HH009
HH011	HH013	HH014	HH014	HH015	HH028	HH029				HH011	HH013	HH014
HH015	HH036	I089	HH036	HH039	HH040	HH042				HH015	HH036	I089
J007	J009	J010	HH045	I060	I065	I075				J007	J009	J010
J011	J012	J013	I084	I089	J007	J009				J011	J012	J013
K018	L010	L011	J010	J011	J012	J013				K018	L010	L011
P010	P014	Q005	K018	L005	L010	L011				P010	P014	Q005
Q006	Q007	Q008	L014	P010	P014	P023				Q006	Q007	Q008
Q013	Q014	Q015	Q003	Q005	Q006	Q007				Q013	Q014	Q015
Q016	R002	R003	Q008	Q013	Q014	Q015				Q016	R002	R003
R005	R007	R008	Q016	R002	R003	R005				R005	R007	R008
R012	R017	R020	R007	R008	R011	R012				R012	R017	R020
R022	R024	R025	R014	R017	R020	R021				R022	R024	R025
R028	R029	R030	R022	R024	R025	R028				R028	R029	R030
R031	R032	R035	R029	R030	R031	R032				R031	R032	R035
R038	R046	S001	R035	R036	R038	R042				R038	R046	S001
T004	T006	T007	R046	S001	T002	T004				T004	T006	T007
T008	T009	T011	T006	T007	T008	T009				T008	T009	T011
T012	U005	U013	T011	T012	T015	T019				T012	U005	U013
V012	W001	W002	U003	U005	U006	U008				V012	W001	W002
W003	X003	X013	U011	U012	U013	U014				W003	X003	X013
X016	X019	X020	U016	U017	V012	V015				X016	X019	X020

Alternative 1			Alternative 3				Alternative 4			Alternative 5		
X021	X022	X023	W001	W002	W003	W004				X021	X022	X023
X025	X026	X028	X003	X011	X013	X015				X025	X026	X028
Y003	Y028	Z011	X016	X019	X020	X021				Y003	Y028	Z011
Z028	Z029		X022	X023	X025	X026				Z028	Z029	
			X028	Y003	Y010	Y011						
			Y014	Y015	Y020	Y028						
			Y029	Z011	Z013	Z027						
			Z028	Z029								

Appendix C – Monitoring Reports & Modeling Data

Appendix C contains a collection of supplemental information used in the development of this resource report. This information was used to support effects analysis, and is cited multiple times throughout the text of this report (monitoring reports). Because these reports and modeling results are not readily available on the internet, they are included here for reference. The list below indicates what is included in Appendix C, and where it is located.

1) Disturbed WEPP modeling parameters, and simplified results
   a) Pages 39-40
2) Full Disturbed WEPP results and summary of treatment and control runs
   a) See separate document, Soils Report Appendix C (Project Record)
3) Monitoring reports
   a) See separate document, Soils Report Appendix C (Project Record)

1) Disturbed WEPP Modeling Parameters & Results (aquatic species areas)

Model runs completed on February 25, 2016. The following are the parameters entered in to Disturbed WEPP to get erosion and sedimentation estimates for a few selected areas adjacent to aquatic species habitat. WEPP is a physically based erosion model which incorporates topography, soils, climate, vegetation and management activity. Results from these model runs do not apply project-wide and are not intended to represent predicted erosion from all treated areas. The objective of this modeling was to get a relative prediction of treated (action alternatives) vs. untreated (control / Alternative 2) sedimentation and erosion rates in areas adjacent to aquatic habitat.

SIERRA NEVADA YELLOW-LEGGED FROG

- Unit CC001 - portion of unit adjacent to Middle Fork Tuolumne River, GIS shows no buffer, so just project design features, BMPs, etc.
    - Alt 1, 3 & 5- All same treatment (thin) = Rx Fire in 2019 then masticate in 2020 (Input low severity fire with high ground cover ~75%) 15 ft. mechanical exclusion. 60% cover within 100ft.
    - Control (Alt 2) – no treatment, modeled in 2019, 6 years post fire. (Input young forest)
- Unit N019 – portion of unit adjacent to Eleanor Creek; ~75-foot buffer is already in place, but should still provide for useful comparison
    - Alt 1- Machine Pile 2021 then Herbicide Site Prep & release
    - Alt 3- Machine Pile then DTFC 2021, Plant & manual release
    - Alt 5 – Same as Alt 1

CALIFORNIA RED-LEGGED FROG

- Unit X028 – looked for steepest/susceptible slope north or south of stream (outflow of Birch Lake)
    - Alt 1, 5 – DTFC treatment in 2016. Alt 3 – Machine pile then DTFC in 2016. Cover & infiltration determined by DTFC, so all action alts the same in model (DTFC = Shrub)
    - Control (alt 2) – No treatment, modeled in 2016 (4 years post fire = Tall grass).
- Unit V012 – small stream channel east side of unit, look for steep/susceptible area
    - Alt 1, 3, 5 – Machine pile followed by DTFC in 2021, 8 years post fire (Input Young Forest) DTFC would improve infiltration slightly, but not improve to Mature Forest condition.
    - Control (Alt 2) – no treatment, modeled in 2021, 8 years post fire (input young forest)

FOOTHILL YELLOW-LEGGED FROG AND WESTERN POND TURTLE

- Unit T009 – north side of unit along stream, look for steep/susceptible area
  - Alt 1, 4 – DTFC treatment in 2016. Alt 3 – Machine pile then DTFC in 2016. Cover & infiltration determined by DTFC, so all action alts the same in model (DTFC = shrub)
  - Control (alt 2) – No treatment, modeled in 2016 (4 years post fire)
- Unit R046 and/or R038 – east side of unit along Corral Creek, look for steep/susceptible area with smallest mapped buffer
  - Alt 1, 5 – DTFC treatment in 2017. Alt 3 - Machine pile then DTFC in 2017. Cover & infiltration determined by DTFC, so all action alts the same in model (DTFC = Young Forest)
  - Control (alt 2) – no treatment, modeled in 2017, 5 years post fire (input Shrub condition)

Appendix C Table 1 – Simplified results of Disturbed WEPP modeling- Erosion & Sedimentation rates

Unit & Treatment	Mean Annual Upland Erosion Rate (tons/acre)	Mean Annual Sedimentation Rate (tons/acre)	Probability of Erosion, First Year After Treatment (%)	Probability of Sedimentation, First Year After Treatment (%)
CC001_YLF_Trt_2	0.267	0.267	90	100
CC001_YLF_Control_2	0.022	0.018	20	20
N019_YLF_Control_1	0.013	0.009	20	20
N019_YLF_Alt1&5_1	0.053	0.053	40	40
N019_YLF_Alt3_1	0.16	0.151	40	40
X028-CRLF_Trt	0.049	0.049	40	90
X028-CRLF_Control	0.022	0.022	30	80
V012_CRLF_Control	0.076	0.076	100	100
V012_CRLF_Trt	0.699	0.641	100	100
T009_FYLF_Control	0.659	0.659	100	100
T009_FYLF_Trt	**1.331**	**1.331**	**100**	**100**
R046_R038_FYLF_Trt	**1.455**	**1.455**	**100**	**100**
R046_R038_FYLF_Control	0.623	0.623	100	100
LostClaim_Trt	**3.044**	**3.044**	**100**	**100**
LostClaim_Control	**1.46**	**1.46**	**100**	**100**

2) Full Disturbed WEPP results and summary of treatment and control runs

See full Appendix C in project record

3) Monitoring reports

See full Appendix C in project record

Appendix C–Monitoring Reports & Modeling Data

The following pages include additional WEPP monitoring data, photo examples of erosion in a DTFC unit, and unpublished monitoring reports that were frequently cited in the Rim Fire Reforestation (45612) Soils Resource Report.

Contents

- Disturbed WEPP Summary Results for Aquatic Species Areas - Alternatives 1, 3, & 5 (Treated).
- Disturbed WEPP Summary Results for Aquatic Species Areas – Alternative 2 (Control).
- Disturbed WEPP Results for single hillslope example in Lost Claim DTFC Unit
- Background info for "Lost Claim Gully"
    - Report received from Todd Ellsworth, March 2016.
- Example Photos of Lost Claim Gully site from 1997 & 2016
- Brown, E. 1993. Soil Scientist. Mechanical Site Preparation Soil Monitoring Report. Internal Unpublished Monitoring Report documentation. USDA Forest Service, Stanislaus National Forest, Sonora, CA.
- Schmitt, G. 1997. Zone Soil Scientist. Memo of Functional Assistance Trip. Internal Unpublished Monitoring Report documentation. USDA Forest Service Pacific Southwest Region, Vallejo, CA.

USFS DISTURBED WEPP BATCH PROGRAM - Summary Results

Project Name Rim REFO_ Treatment(Alt1,3,&5)_Runs

Location Rim Fire, Groveland RD CA

Watershed Tuolumne

Climate Summary

Modified by Rock:Clime on February 23, 2016 from
HETCH HETCHY CA 43939 0 T MAX 48.47 52.80 56.41
63.17 70.12 78.11 86.52 86.18 81.19 71.68 58.39 49.52 deg F
T MIN 28.19 29.63 32.05 37.11 43.06 49.23 55.71 55.00 50.15 42.11 33.93
29.68 deg F
MEANP 5.63 5.69 4.91 3.36 1.16 0.46 0.13 0.24 0.83 2.10 5.37 5.47 in
WET 8.94 9.49 10.67 7.63 6.09 2.90 0.86 1.33 2.77 4.77 6.89 8.41 days
Latitude 37.91 Longitude 119.94 Elevation 3805.0 ft

Total Hillslope Area 155.45 acres consisting of 13 hillslopes

Mean Annual Averages for Watershed

Precipitation	37.92	inches
# of storms	721	
Average runoff from rainfall	0.91	inches
Average # of runoff events	37	
Average snowmelt runoff	1.22	inches
Average # of snowmelt runoff events	30	

	Average tons/acre	Total tons
Upland Erosion	0.70	98.12
Sediment Delivery	0.69	96.84

Return Period Analysis

	Average (tons/acre)		Total (tons)	
	Erosion	Sediment Delivery	Erosion	Sediment Delivery
10 year	1.62	1.55	227.44	218.58
5 year	1.43	1.37	204.33	198.14
2 year	0.66	0.66	95.24	94.59
1 year	0.09	0.08	8.34	8.06
Average	0.70	0.69	98.25	96.83

Probability of Occurrence in First Year Following Disturbance

	Probability Range	
Runoff	40 - 100	%
Erosion	40 - 100	%

HERRERA

USFS DISTURBED WEPP BATCH PROGRAM - Summary Results

Project Name Rim REFO_ Control/No Action Units

Location Rim Fire, Groveland RD CA

Watershed Tuolumne

Climate Summary

Modified by Rock:Clime on February 23, 2016 from
HETCH HETCHY CA 43939 0 T MAX 48.47 52.80 56.41
63.17 70.12 78.11 86.52 86.18 81.19 71.68 58.39 49.52 deg F
T MIN 28.19 29.63 32.05 37.11 43.06 49.23 55.71 55.00 50.15 42.11 33.93
29.68 deg F
MEANP 5.63 5.69 4.91 3.36 1.16 0.46 0.13 0.24 0.83 2.10 5.37 5.47 in
WET 8.94 9.49 10.67 7.63 6.09 2.90 0.86 1.33 2.77 4.77 6.89 8.41 days
Latitude 37.91 Longitude 119.94 Elevation 3805.0 ft

Total Hillslope Area 141.00 acres consisting of 11 hillslopes

Mean Annual Averages for Watershed

Precipitation	37.92	inches
# of storms	721	
Average runoff from rainfall	1.01	inches
Average # of runoff events	26	
Average snowmelt runoff	1.48	inches
Average # of snowmelt runoff events	35	

	Average tons/acre	Total tons
Upland Erosion	0.32	38.16
Sediment Delivery	0.32	37.99

Return Period Analysis

	Average (tons/acre)		Total (tons)	
	Erosion	Sediment Delivery	Erosion	Sediment Delivery
10 year	0.75	0.74	90.29	89.30
5 year	0.61	0.60	71.71	71.19
2 year	0.30	0.29	34.66	34.00
1 year	0.04	0.04	5.61	5.48
Average	0.32	0.32	37.96	37.98

Probability of Occurrence in First Year Following Disturbance

	Probability Range	
Runoff	40 - 100	%
Erosion	20 - 100	%

HERRERA

Disturbed WEPP Results

User inputs

Location	Near Buck Meadows CA + Modified by Rock:Clime on February 23, 2016 from HETCH HETCHY CA 43939 0 T MAX 48.47 52.80 56.41 63.17 70.12 78.11 86.52 86.18 81.19 71.68 58.39 49.52 deg F T MIN 28.19 29.63 32.05 37.11 43.06 49.23 55.71 55.00 50.15 42.11 33.93 29.68 deg F MEANP 5.63 5.69 4.91 3.36 1.16 0.46 0.13 0.24 0.83 2.10 5.37 5.47 in # WET 8.94 9.49 10.67 7.63 6.09 2.90 0.86 1.33 2.77 4.77 6.89 8.41 days Latitude 37.91 Longitude 119.94 Elevation 3805.0 ft				
Soil texture	clay loam				
Element	Treatment	Gradient (%)	Length (ft)	Cover (%)	Rock (%)
Upper	good grass	15 25	330	10	20
Lower	poor grass	30 40	50	40	20
Description	Rim Reforestation Demo (Lost Claim, Feb 2016) - Prediction				

Mean annual averages for 10 years

			Total in 10 years	
37.92	in.	precipitation from	721	storms
1.80	in.	runoff from rainfall from	67	events
2.16	in.	runoff from snowmelt or winter rainstorm from	44	events
2.915	t ac^{-1}	upland erosion rate (0.655 kg m^{-2})		
2.915	t ac^{-1}	sediment leaving profile (75.89 kg m^{-1} width)		

Return period analysis based on 10 years of climate

Return Period	Precipitation (in.)	Runoff (in.)	Erosion (t ac^{-1})	Sediment (t ac^{-1})
10 year	50.34	8.47	5.81	5.8089
5 year	48.52	6.98	5.23	5.2296

2 year	38.28	4.21	3.03	3.0249
1 year	25.06	0.48	0.71	0.7078
Average	37.92	3.96	2.91	2.9148

Probabilities of occurrence first year following disturbance based on 10 years of climate

Probability there is runoff	100 %	
Probability there is erosion	100 %	
Probability there is sediment delivery	100 %	

Return to Input Screen

[slope | soil | vegetation | weather | response || WEPP results]

Disturbed WEPP 2.0 Results v. 2014.04.14 based on WEPP version 2010.100 , CLIGEN * version 4.31 *
http://forest.moscowfsl.wsu.edu/fswepp
10:00 am Wednesday February 24, 2016 Pacific Time
Disturbed WEPP Run ID wepp-74552

Background info for "Lost Claim Gully"

* An interesting "cateana" of soils. Very rocky with a dense clay subsoil thin "A": horizon at the top and shoulder slope, less rock but still a dense subsoil on the back slope, little rock with a thicker "A" horizon (more productive) on the footslope.

* Mapped as Bandarita soil series Probably 3 different soil series present on the site.

* Tilled in the fall of "96.

* Erosion noticable in Dec. exacerabated by the early Jan. storm:. main gully in the lower part of the unit approximattely 3 and 1/2 feet deep and 2 to 2 1/2 feet wide in places. Side gullies 1 to 2 feet wide and 1-2 feet deep in deeper soils at bottom of the unit.

* Several site visits with Silv. Hydrology and Soils to formulate an erosion treatment prescription.

* Treatment consisted of 2 parts. (fall of 1997)

Part 1: Decided to retill top (rocky) area to obliterate the inciepent gullies and to increase infliltration. Also filled in and tilled through the larger gullies down slope to obliterate gullies and increase infiltration.

Part 2: Place straw wattles in low areas to redistribute water to ensure "old" gullies don't reform- Seed with perrenial grass Elymus glaucus (Blue WildRye) from seed collected on Groveland R.D. Placed rice straw in and adjacent to the main gullies to intercept rainfall, help keep top soil in place. and protect the seed. Rice straw is essentially weed free.

Probable causes of the erosion:

1. Rock on top and shoulder slopecoupled with dense subsoil made it difficult for the tiller to achieve suitable tilling depth. Soil profile saturated with moisture causing runoff.

2. Rock on the top and shoulder slope effectively shed the rainfall causing downslope erosion (similiar to a rock outcrop or compacted area.

3. Long, continuous slope length with 30% slopes through out the shoulder and backslope

4. Highly erosive winter storms throughout 1997 (esp. rain on snow event in early Jan.)

5. Slight devation off the contour. The deviation is well within contract specs., however on steeper slopes a slight varation 1-5% can concentrate water to a low point and blow out the furrows.

6. Lack of protective soil cover

7. Others???

1.

RESULTS

Crossed our fingures before the winter of 1997-98. We experienced an "El Nino" winter that tested our treatments.

1. Treatments pretty much held. Yeah!! A few incipient rills formed from throught the heavy rain fall winter.

2. Follow up treatment in Feburary of 1998.:. Consisted of: 1. Filling in inceipent rills and gullies. Placing rice straw over treated areas. 2. Placing soils and straw in main gully where "settling" of the previous treatment occured.

3. Rice seed in rice straw WILL germinate!! Can't survive for very long in a forest environment.

4.. Cows visited the area in the early summer. Notice the hoof prints in the straw wattles!!. They ate some of the straw and grass seedlings

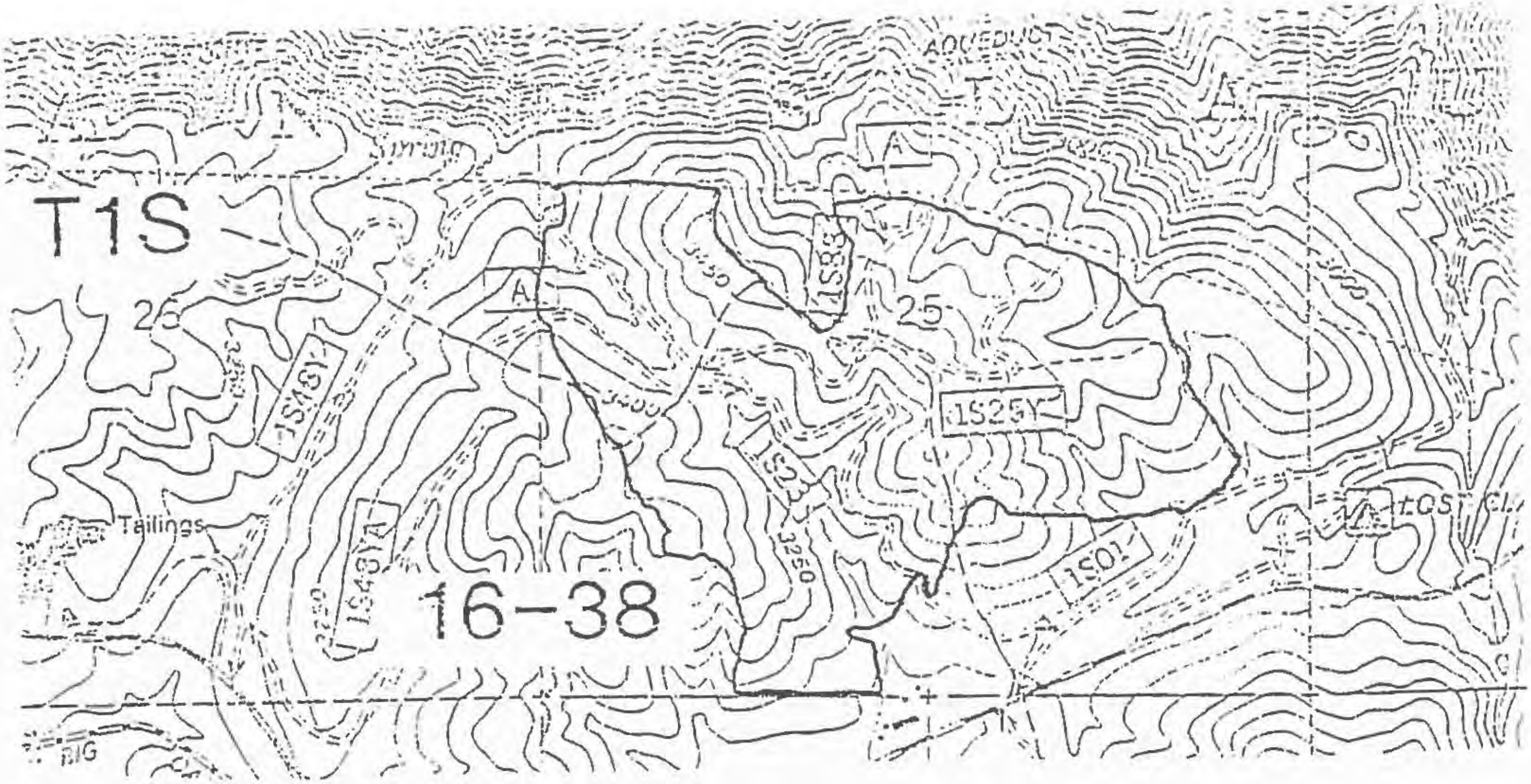
What you see is the effectiveness of the erosion control treatments (except for the cows!!).

CONCERNS (treatment)

1. Lack of good grass seed germination. Probable causes: 1. straw inhibitting growth (carbon/nitrogen ratio on the soil surface and possible allopathy I'm still researching both of these!!) 2. desication 3. Competition from rice seedlings. 4 Others????

COST OF REHAB. TREATMENT

Treatment cost was $2000-2,500. This includes the tillage, straw wattles, rice straw, seed and an approximatley 20 person crew for 2 and 3/4 days. Watershed paid for tillage, straw wattles, rice straw and seed. The initial treatment took 1 day for the tillage and 1 day for the seed and straw. Follow up treatment took 3/4 of a day for approximatley 20 people.



16-38 Pile, till, and cultivate, Dec? 1996, $361/ac
Earliest erosion observed in December but erosion increased with the January 1997 storms.
Planted 1997
Erosion re-shaped and re-tilled, September 1997
Rehab and seeding, November 1997
Planted re-tilled areas, March 1998
Follow-up rehab, 1998
Stocking as of September 1997 230 tpa

Soil	Surf.Tex	Prod.	Slope %	Equipment	Watershed
Bandarita	L	Low	25-35	Subsoil	S. F. Tuolumne River

Example Photos of Lost Claim Gully Site, 1997 & 2016

Before: Fall 1997

Spring 1998: After straw treatment (see accompanying document for additional details)

Spring 1998

Spring 1998

1997, before treatment

1997, before treatment

Gully formation in 2016, same general area as photos above.

In 2016, 5+ gullies have formed, several are a few hundred feet long, and up to 2 feet deep x 18 inches wide.

United States Department of Agriculture | Forest Service | Stanislaus National Forest | Groveland Ranger District
24545 Highway 120
Groveland, CA 95321
209 962-7825

Reply to: 1950
2550

Date: July 29, 1993

Subject: Soil Monitoring, Groveland Mechanical Site Preparation

To: District Ranger
District Silviculturist
Forest Watershed Staff Officer
Forest LMP Officer

Attached you will find the soil monitoring report for the Groveland Mechanical Site Preparation Project of 1992 by Edward Brown, Soil Scientist. As noted in the report, not all soil quality standards were met by this project. In addition, several operational quidelines (management requirements) from the Environmental Assessment had not be practiced in some of the units observed.

Corrective measures are already being implemented on some of the units treated last year, which experienced accelerated soil erosion. The Contract Officer's Representative for the 1993 Mechanical Site Preparation Project has been briefed on the need to ensure full operational guideline implementation in this year's contracts.

In my professional opinion, the results of this monitoring point out the concern that use of ripping/tillage for vegetation control in areas that are not severely compacted, may adversely effect soil productivity. When originally implemented on this Forest, deep-tillage was used specifically for amelioration of severe soil compaction, and has repeatedly been demonstrated to create improved soil quality under those very specific conditions. I recommend that future projects only consider ripping/tillage for vegetation control on areas that also are severely compacted and are in need of amelioration.

/s/ R.Griffith

ROBERT W. GRIFFITH
Soil Scientist

United States Forest Stanislaus Groveland Ranger
District
Department of Service National 24545 Highway 120
Agriculture Forest Groveland, CA 95321
209-962-7825

Reply to: 2550 **Date:** 7/27/93

Subject: MECHANICAL SITE PREPARATION SOIL MONITORING REPORT

To: DISTRICT SOIL SCIENTIST

SUMMARY

Deep soil ripping with winged ripper shanks was employed to uproot vegetation in preparation for planting of coniferous timber trees in the Groveland Mechanical Site Preparation project of 1992. Soil quality monitoring was required in the Mechanical Site Preparation EA. Monitoring was implemented to sample the effectiveness of operational guidelines that were required during the ripping operations. Soil properties measured included: soil structure, soil cover percentage and soil woody materials. Erosion hazard rating was also calculated on each unit sampled.

Soil porosity was sufficiently maintained by management practices. Effective soil cover, large woody material and small woody material were not present in sufficient quantities. Several operational guidelines from the Environmental Assessment were not practiced on the units observed.

PROCEDURE

Tilled unit numbers were selected at random from a hat until the number of units required for sampling was obtained. Numbers were selected until 50% of the estimated high erosion hazard units and 10% of all other units was attained, seven and nine respectively, as required in the monitoring plan.

Each unit was traversed on the ground to find areas of treatment and locate a representative area to sample. A stick was tossed in the middle of the area and the direction the stick pointed when it fell to the ground was marked. A 400 foot long transect was located along the bearing indicated and sampling would begin at the point where the stick landed. Five 1/10 acre circular plots were located along the transect at 0, 100, 200, 300 and 400 foot measurements.

Each 1/10 acre circular plot was sampled for large woody material 20 inches in diameter or greater and 10 feet or longer. (Decay class and species of the logs was also noted.) A toe-point sample of the small woody material cover and total ground cover was taken at the center of each plot. A hole was dug to twelve inches depth to assess the soil structure in each plot.

ANALYSIS AND RESULTS

Soil monitoring data were extrapolated and compared with per acre requirements under Soil Quality Standards using simple proportions to estimate the area passing these guidelines. Soil structural class, used as a proxy estimate of soil porosity, was compared to soil structural classes noted in soil surveys of the district. Any significant increase in ped size, grade or change to a more dense shape class was considered to be a decrease in porosity.

TABLE 1. RESULTS OF SAMPLING AND COMPARISON TO SOIL QUALITY STANDARDS

	POROSITY	COVER	LWM	SWM	EHR	ESTIMATED
16-22	+	-	-	-	H	M
18-2	+	+	-	-	L	H
18-6	+	-	-	-	M	H
19-7	+	+	-	-	L	H
19-10	+	+	-	-	M	H
19-17	+	-	-	-	M	H
19-62	+	+	-	-	H	H
20-8	+	+	-	-	M	H
20-17	-	-	-	-	M	L
23-19	+	-	-	-	H	H
25-63	+	-	-	-	M	M
26-2	+	-	-	-	H	M
26-8	+	+	-	-	M	M
26-52	+	-	-	-	M	M
32-44	+	-	-	-	H	M
32-117	-	-	-	-	H	M
% Passing -	**88%**	**38%**	**0%**	**0%**		

+ = passing SQS
- = not passing SQS

L = Low
M = Medium
H = High

POROSITY - Porosity standards were met on 88% of the units based on the proxy sampling of soil texture. These units show soil structure conducive to hydrologic function and plant growth.

SOIL COVER - Soil cover on 38% of the units was estimated to be sufficient to prevent a high erosion hazard. Sheet erosion has removed fine soil materials and left gravel and rock pavements. Shrub vegetation was not all removed by operations and vegetation is recovering.

LARGE WOODY MATERIAL - Large, downed logs were not present in sufficient amounts on any of the units. Logs per acre averaged 1.25 for all units, with the one high unit estimated at 4 logs per acre, still one log below sufficient.

SMALL WOODY MATERIAL - Small woody material was insufficient in all of the units sampled. Materials averaged 9% for all units with a high of 21% in one unit, which is 29% below sufficient amounts.

EROSION HAZARD RATING (EHR) - During the monitoring study, 40% of the units were ranked in the high, 53% in the moderate and 13% in the low EHR categories. When compared to the estimates based on soil surveys, only 31% of the estimated EHRs were correct, 38% were overestimated and 31% were underestimated (overestimation being a high EHR estimation from survey data, but only a medium EHR calculation on the ground). Of the eight units that were estimated as high EHR in the EA, only two were estimated as high EHR on the ground

DISCUSSION

POROSITY - Two units that failed the standard appear to have been ripped when the soil was wetter than the plastic limit, counter to the operation guidelines of the EA. The molding of moist soil by the machinery has left hard clods that will break down slowly with weathering. The most common porosity problem noted was crusting from raindrop impact on the exposed soil. Some of the sites that did not have strong soil structure or compaction appear to have had the inherent soil structure pulverized by the ripping. This effect may result in eventual hardening of the soil after moisture settles soil particles and clays cement it all together. Clayey subsoils of some areas hardened after being exposed to air by the ripping, which lowered porosity and permeability.

SOIL COVER - The ripping operation caused former soil cover of grasses and small woody materials to be incorporated in the soil profile. Many units did not show any regeneration of grasses this season, but will probably be covered by grasses and annual forbs next season. All soils that were left denuded of soil cover showed drop impact crusts that could extend as deep as 1/2 inch. Most units that received high EHR during the monitoring study had effective soil cover removed by the ripping, which has exposed the soil surface to drop impact and sheet erosion. Many units exhibit localized sheet and rill erosion characterized by gravel pavements, sediment basins, puddles and rill channels. Gravel pavements have become the first effective soil cover on units where fine soil particles have washed away and rocks, gravel or buried wood are exposed.

LARGE WOODY MATERIAL - Large logs are rare in most areas. There are not many recruitable snags or green trees.

SMALL WOODY MATERIAL - Small woody material will recover more quickly than large woody material, but it may be a decade before this recommended soil quality standard is met in most areas.

EROSION HAZARD RATING - The EHR for each unit was calculated on site during the sampling. Estimations of EHR done for the EA were taken from soil surveys. The large proportion of misestimations (69%) using soil survey data suggests that the soil survey is not reliable as the sole source of information. The permeability and inherent strength of the soil are definitely factors in this estimation. Soils with inherently high strength may have a low EHR but may also be slowly permeable, causing higher overland flows and erosion on slopes. Soils with inherently low strength and high EHR have more porosity to absorb water at higher rates and slow erosion. It is recommended that erosion hazard ratings be done on site to ensure accuracy and provide advance data for analysis.

GENERAL - Most tillage that was done left minimal furrowing and covered the unit area well. However, the effectiveness of killing pest vegetation with the winged rippers is not being monitored. Some units have fair quantities of shrub species that will add to soil cover sooner than units that were left totally denuded.

Ripping was not done consistently on the contour as recommended in the operation guidelines of the EA. Runoff has cut rills into the loosened topsoil where furrows concentrate the flow onto loosened soil. Unripped buffer strips that were prescribed in the operation guidelines of the EA to be left below road drainage areas were not required in the contract and not left. Two units show rill erosion where the roads drain onto the loosened soil. The soils that show the most erosion are those that contain the higher clay contents and have inherently slow permeability.

/s/ E. Brown

EDWARD K BROWN
Soil Scientist

SPEED MEMO

TO:District Ranger Groveland Miwok	DATE:JULY , 1997
FROM:Gary Schmitt Zone Soil Scientist	SUBJECT:Functional Assistance Trip

At the request of Todd Ellsworth and Alex Janicki, I made a functional assistance trip to the Stanislaus, on March 27 and 28. The objectives of the trip were to evaluate deep-tillage units that experienced accelerated erosion this past winter

Results / Conclusions

Basically some tilling is occurring on soils that should not be tilled, the operations are not being supervised by someone who knows critical soil concerns and/or how to recognize when they are not being addressed, contract specifications are not always being met, and some tilled areas may not be meeting Soil Quality Standards as reguards to integrity of the A horizon, organic matter, and erosion.

The Groveland RD 1996 tilling operations, which include brush piling may not be meeting Soil Quality Standards. Accelerated erosion is occurring, surface organic matter has been reduced drastically and soil organic matter may have been reduced beyond the 15% allowed in the standards. There are a number of factors that are/have contributed to the problems observed. Some of these factors are removal of the thin A horizon (from piling of topsoil or turning under the topsoil), tilling on shallow soils, tilling on soils with a restrictive layer (such as A dense subsoil), lack of tillage depth, removal of organic matter from soil surface, high volume of coarse/rock fragments in soil, concentration of slope runoff, steep slopes, and most important not having an experienced Soil Scientist or a COR trained in recognizing critical soil concerns to oversee the operation. If the COR is not an experienced Soil Scientist she/he should spend time with the Soil Scientist to get some training on what soil characteristics are critical to a quality product and how to recognize these characteristics.

We also visited some sites on the MiWok RD that were tilled several years ago. Many of these sites still exhibit improved soil tilth over before till conditions. The sites that appear to be holding good tilth are generally on the deeper soils such as the Josephine. Tilling on the Mariposa soils show some tilth improvement, however many of the problems stated in the previous paragraph apply.

The recovery of ground cover seems to be quite variable, on past tilling on both Districts.

Recommendations (site specific recommendations will be made by the District Soil Scientist)

A. Recommendations for FY96 Tilling on Groveland

1) If piles are not topsoil free, then re-spread topsoil

2) Re-till badly eroded areas to remove rills and small gullies (get control of water) and spread jute in low areas that will concentrate water. It is desirable to break up the gully and rill patterns to keep water form concentrating in these areas.

3) Seed areas that are expected to concentrate water.

B. Recommendations for future tilling projects:

1) To meet Contract Specifications the COR must make a closer inspection of the brush piles. Piles that have excessive topsoil do not meet specs., and the topsoil in these piles should be re-spread.

2) Recommend consulting with Miwok on how they achieved a greater depth of tilling on their sites.

3) Strip till on all slopes over 20%. Use the Erosion Hazard Rating System to help determine width of till/leave strips.

4) Have a Soil Scientist, or technician trained by a Soil Scientist with the operation at all times. This is necessary to identify shallow soils, rocky areas, restrictive layers, or other site specific concerns that may arise.

5) Do not till Mariposa soils, shallow soils, or extremely rocky soils. observation made over the past few years revealed that tilling the moderately deep Mariposa soil can cause significant problems such as; mixing of the thin A horizon, erosion problems, rock brought to the surface, and a loss of site productivity. Preliminary monitoring of tillage on Bandarita soils showed that this practice may not produce desired conditions. This soil has a thin A horizon and a dense, clayey subsoil. It is difficult to get the desirable penetration, which will lead to excessive runoff and erosion. These soils also have thin A horizons which are lost easily when exposed. This is serious from both the soil productivity and sediment standpoint. Vegetation control is best completed by the use of herbicides.

C. Monitoring recommendations:

Run transects to monitor Soil Quality Standards

1) Organic Matter for Erosion Control

Determine percent soil cover for erosion control

2) Organic Matter for Long Term Soil Productivity

Determine presence and depth of A horizon, and compare to natural conditions.

Determine if soil structure is present and percent of area.

Continue with Cal Poly study to monitor organic matter recovery on MiWok plots.

Tilling Project - Groveland RD

On March 27, Alex Janicki, Todd Ellsworth and I did some monitoring of the Groveland RD 1996 tilling projects. Following are our observations in these areas.

Stop 1. Behind Buck Meadows - unit 16-45-Bandarita Soil Series

This Unit had serious erosion throughout the tilling project. The most severe unit was visible from Highway 120. This area had one major gully that was an average of about 3 and 1/2 feet deep, 2 to 2 and 1/2 feet wide, and about 150 feet long. There were side gully's that were about 1 to 1 and 1/2 feet wide and 1-2 feet deep. There were also numerous other rills that were about 6 inches to one foot deep and wide.

Topsoil piled during brush piling operations was 2 to 4 feet high on the lower portion of the slope. Upper slopes had piles estimated up to about 13 feet high by 20 foot wide. Areas with shallow soils had little (less than 2 inches) to no topsoil left on the site. The deeper soils lower on the slope also had severely reduced topsoil layers. The Bandarita Soil Series only has a 3" A Horizon.

Depth of tillage was measured with a tile spade penetrating the soil. In most cases, the spade could penetrate to a depth of 12" with a few spots as low as 8 and as high as 22". The contract required a tillage depth of 24" throughout the unit. The tiller did not penetrate the dense clay subsoil. Several factors contributed to the erosion on the lower slopes. The following is a list of potential problems that lead to the excessive rilling and gullying.

1) Depth of tilling on upper slopes

a) Soils were shallow (less than 20 inches) in places and it was physically impossible to get penetration.

b) rock content affected depth of penetration. It may have been physically impossible to get the implement to penetrate, and/or power of tractor may have been reduced.

c) Equipment operation may have been less than desirable.

d) A Soil Scientist or COR should have checked the tillage depth more closely on the steeper slopes.

e) Where the soils were 20 to 30 inches deep, there was also a dense subsoil layer that was not penetrated.

2) Tillage on lower slopes

A) On the deep soils (lower on slope), tillage did not penetrate the heavy textured clayey subsoil and there was not enough organic matter cover.

2) Concentration of water

a) Slope of till strips concentrated and flowed water to low points. A slight, 1-3% variation off the contour can concentrate water on a steep >20% slope.

b) Shallow tilled areas and lack of tilth did not let water enter soil or percolate through it.

c) Lack of protective ground cover to protect soil against detachment and movement.

d) A long, continuous slope length with slopes up to 30%

Stop 2 Brush Ridge. Tilled in 1996 Unit 27-41 Mariposa-Jocal Soils
Unit 27-22 tilled in 1994

Soils in unit 27-41 are shallow to moderately deep, with depths running around 20 inches. Erosion is slight in this unit and it appears that it was a " dirty" tractor piling job, leaving plenty of organic material in and on the soil surface. The "dirty" piling leaves organic material on the surface, however it is makes it difficult to till without mixing the soil. Bear clover is coming back quickly and should protect the site in several years.

We next visited an adjacent site, unit 27-22, that was tilled in 1994. There was little difference in density and infiltration from this tilled site to an untilled site. The shovel penetrated about 6-10" on the site that was tilled in 1994. The site that wasn't tilled allowed little penetration of the shovel. So, compared to the natural condition, there is a slight difference, however, it may not be significant.
We compared an untilled site with the recent tillage and found that there is about 3 inches of A horizon in the undisturbed and 0 to 1 inch in the disturbed areas.

At this site we had a discussion about tillage of landings and skid trails and how that differed from tilling for vegetation management. Tillage of skid trails and landings restores the natural infiltration of a compacted

soil and provides a desirable seed bed for conifer establishment. Tilling for vegetation management may provide a desirable seed bed for conifer establishment, but it may not increase infiltration beyond what was there before the tilling. It initially increases infiltration, however, after a few years that benefit appears to diminish.

Tilling Project-Complex Fire, Miwok RD

On Friday March 29, Alex Janicki, Todd Ellsworth and I monitored tilled areas on the Complex Fire (tilled in 1994 or 1995). Following are our observations.

Stop 1. Research plot D of Cal Poly study, above 1N01 approximately one half mile before Hunter Creek Bridge

This is mapped as a deep Sites soil at 3250 feet elevation. The area was tilled about 5 years ago. The tile spade was used to check soil density. The shovel sank to 16 inches plus. Soils had good tilth and had a good cover of grass. Trees were doing well on a 10 foot spacing. The area was recently interplanted to a 5 foot spacing. Dave Campodonico said that tilling specs for this area was a 2 foot plus depth on the first pass using winged rippers and 1 and 1/2 feet depth on the second pass using a cultivater.

Stop 2 Hunter Creek Drainage Road 1N01 T1N, R17E, S20

This is mapped as a deep and moderately deep Josephine soil at 4000 feet elevation. Shovel sank in to 16 inches plus. This area was tilled about 5 years ago. The site was still bare and eroding after 5 years. Portions of this site are not meeting Soil Quality Standards.