Salt Timber Harvest and Fuel Hazard Reduction Project

Soil Resource Report

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for:

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Abstract

Soil productivity is maintained by adhering to the regional soil quality standards (USDA Forest Service, FSH 2509, 1995) for onsite erosion, compaction, and organic cover.

Introduction

Soil is a fundamental part of a forest ecosystem; soil health and productivity influence the long-term forest productivity. The purpose of this report is to document the analysis of environmental consequences to the soil resources of the proposed Salt Timber Harvest and Fuels Hazard Reduction Project. It is intended to contain the technical information to support the rather brief and non-technical evaluation of effects described in Chapter 3 of the Environmental Impact Statement (EIS).

The general nature of soils of the project area is also described briefly. Those soil properties that have a direct influence on management practices are described along with the specific mitigation measures or Best Management Practices (BMPs).

Issues

Key issue #5, raised during public scoping, is related to soils:
Construction of new temporary roads may negatively impact … soil health…
The issue indicator used to analyze this issue is:

- Miles of temporary road and resulting acres of detrimental soil disturbance.

Public comments also raised the analysis issue that yarding with tractors could negatively impact soil health and productivity.

Policy and standards that guide soil analysis

Management actions must occur in conformance with applicable law, regulation, policy, guidance, and management direction. This regulatory framework determines the overall objectives and standards and guidelines applied to project activities and resource management. Elements specifically relevant to the soil resource are described here.

Specific measures, indicators, and thresholds are established in assessing soil condition, and evaluating the effects of the proposed project on the soil resource—what gets looked at, why, and interpretation of what it means to soil quality and site productivity.

The National Forest Management Act of 1976[1] (NFMA) recognized the fundamental need to protect, and where appropriate improve, the quality of soil, water, and air resources. With respect to soils, NFMA requires that the Forest Service manage lands so as not to impair their long-term productivity. Further, activities must be monitored to ensure that productivity is protected. This law led to subsequent regulation and policy to execute the law at various levels of management.

The National Soil Management Handbook (FSH 2509.18) defines soil productivity and components of soil productivity, and establishes guidance for measuring soil productivity (USFS, 1991). In determining a significant change in productivity, a 15% reduction in inherent soil productivity potential will be used as a basis for setting threshold values. Threshold values would apply to measurable or observable soil properties or conditions that are sensitive to significant change. The threshold values, along with aerial extent limits, would serve as an early warning signal of reduced soil productive capacity, where changes to management practices or rehabilitation measures may be warranted.

Management activities have potential to cause various types and degrees of disturbance. Soil disturbance is categorized into compaction, displacement, puddling, severe burning, and erosion. Direction was

[1] http://www.fs.fed.us/emc/nfma/includes/NFMA1976.pdf

established that properties, measures, and thresholds relative to these disturbance types would be developed at the Regional and Forest levels, known as Soil Quality Standards.

The R5 Soil and Water Handbook (FSH 2509.22) directs that measures be taken to avoid detrimental soil disturbance and to evaluate management effects on soil productivity, soil hydrologic function and soil buffering capacity. For this project, all evaluations of soil productivity also address concerns of hydrologic function and buffering capacity. Hydrologic function and WEPP are discussed in the hydrology report. Soil buffering capacity is directly proportional to the amount of organic matter in soil and humus and relates to cation exchange capacity. Coarse wood, surface organics (duff or litter), and soil organic carbon (SOC) directly relate to buffering capacity.

Region 5 Soil Management Handbook Supplement

The Region 5 Soil Management Handbook Supplement (FHS 2509.18-95-1) establishes Regional objectives for the Soil Management Program and Regional Soil Quality Analysis Standards (SQAS). These analysis standards are intended to help determine if ecosystem health and long-term productivity are being maintained. The mission of soil resource management has aspects in common with fuels management, watershed management, and water quality.

SQAS provide measures and threshold values that indicate when changes in soil properties and soil conditions may result in significant change or impairment of key soil functions of soil productivity and hydrologic function. Soil disturbance is considered “detrimental” if thresholds are exceeded and subsequent impairment of soil functions is judged likely after a soil & site specific assessment. Detrimental disturbance refers to the severity of impacts, which may be very small scale in occurrence.

The extent of detrimental soil disturbance shall not be of a size or pattern that would result in a significant change in key soil functions for the activity area. Note that the activity area is the scale at which impacts are ultimately assessed, defined as the area where soil disturbing activities take place, such as a timber harvest unit in a sale area or a burn area within a prescribed burn project; system roads, trails, and other areas not dedicated to growing vegetation (other dedicated uses) are not included as part of an activity area.

Both severity and extent of detrimental disturbance are important considerations that must be evaluated together to assess potential adverse impacts on soils of the activity area. As such, detrimental disturbance can be allowed on a small portion of a unit which does not constitute adverse impacts; conversely, minor disturbance can be allowed in most of a unit which likewise do not constitute adverse impacts. Aerial extent limits for different disturbance types are not established in the R5 handbook supplement.

SQAS use the following soil properties, conditions, and threshold values to evaluate management effects on key soil functions of soil productivity and hydrologic function.

Soil Productivity

- Maintain sufficient soil cover to prevent accelerated soil erosion from exceeding the rate of soil formation. [erosion standard]
- Maintain at least 90% of the total soil porosity found under natural conditions, as measured at 4 to 8 inches below the soil surface. [compaction standard]
- Maintain organic matter in kinds and amounts sufficient to prevent significant nutrient cycle deficits, and to avoid detrimental physical and biological soil conditions.
- Soil organic matter in the upper 12 inches of soil is at least 85 percent of the total soil organic matter found under undisturbed or natural conditions. [displacement standard]

- Fine organic matter occurs on at least 50 percent of the area; this includes litter, duff, and woody material < 3 inches diameter. [nutrient cycling standard]
- Large woody material, when occurring in the forested area, is at least 5 logs per acre in contact with the soil surface; and represents the total range of decomposition. Adjust the number of logs/acre to account for ecological type potential. [soil biology standard]
- Large woody material and fine organic matter may be reduced to meet fuel management objectives, except when necessary for essential erosion control.
- Maintain soil moisture regime and drainage classes where plant growth or plant community composition may be dependent upon natural conditions.

Soil Hydrologic Function

- To avoid accelerated surface runoff, infiltration and permeability are not reduced to ratings of 6 or 8, as defined in R5 Erosion Hazard Rating (HER) system.

Application of specific practices and prescriptions to meet SQAS may be adjusted if necessary to meet multi-resource objectives.

The Shasta-Trinity National Forest Land and Resource Management Plan (LRMP) has a goal to maintain or improve soil productivity and prevent excessive surface erosion, mass wasting, and cumulative watershed impacts (USFS, 1995b, page 4-4). Shasta Trinity Forest Plan standards (USFS, 1995b, p. O1-O2) tier to the regional standards published in 1995 (USFS, 1995a). In addition, the Shasta Trinity Forest Plan standards clarify the aerial extent for non-productive dedicated uses such as trails and landings; these include 15 percent for even-aged systems and 20 percent for uneven aged systems (USFS, 1995b, page 4-25). The LRMP tiers to handbook direction for soil management (USFS, 1995a).

INFORMATION USED

Soil information for the Salt Activity Area is available in the Soil Survey of Shasta-Trinity Forests Area report (Lanspa, 1994). This survey provides general information about the soils, their capabilities and their limitations. The soil information contained in the Soil Survey of the Shasta-Trinity Forests Area, while not intended for project level work, does provide a sound background for project level work with further field investigations. The information in the Soil Survey directs field work to the most sensitive areas to management.

Serpentine soil survey identifies several soil types on the Salt analysis area with serpentine properties or parent material (USFS, 2004).

Geographic information system (GIS) data includes: Ecomap, Serpentine soil covers, Soil survey, DEM, and contours.

Field Work

Method 1: Utilized the Soil Compaction Monitoring Protocol for the Shasta-Trinity National Forest (Young and Rust, 2007). Five 200ft transects were evenly distributed throughout the project area on a Holland loam soil (map unit 182, Marpa-Holland complex, 20 to 40% slopes). Holland soils have the highest compaction hazard rating within the project area and the majority of the project activity units are located on map unit 107 and 182. By sampling Holland soils throughout the project area, past activities that caused the most compaction can be accurately portrayed. Each transect end point was recorded in a GPS and located to capture all disturbance classes of undisturbed, disturbed, and skid trails. Twenty points were sampled per transect for a total of 100 samples used to measuring bulk density. (Bulk density is expressed as g/cc3 and is used to calculate porosity, which is expressed as total porosity (or void space) of the soil).

Bulk density was sampled in the 4 to 8 inch zone at each 10-foot increment along each 200 foot transect. Bulk density values for each disturbance level was averaged for the entire area sampled. Porosity change was calculated by using the difference between undisturbed and disturbed classes (Table 2).

Soil map units were evaluated for accuracy with soil pit descriptions and total cover was evaluated to determine percent cover, depth of duff, large woody debris (LWD) per acre, along with total fuel per acre on selected project units (Appendix D). Soil erosion was evaluated on visual indicators of surface erosion using rills, gullies, pedestalling, soil deposition, erosion pavement or loss of the surface "A" horizon. These indicators were evaluated by visiting selected project units (see Appendix D).

Method 2: A protocol developed for the Idaho and Montana by Rocky Mountain Research Station (USFS, 2008) was used to describe current soil conditions in the Salt project. This method used paced transects with spade-point sampling. It relies heavily on qualitative indicators of disturbance. Initial field time was spent attenuating visual soil indicators to determine detrimental disturbance.

Four categories were used for classifying soil disturbance as outlined in the Region 1 protocol: Classes 0 though 3. Class 3 was considered detrimental based on initial field reconnaissance and professional judgment. Class 2 was moderate disturbance, Class 1 was low disturbance, Class 0 was none. Much of the disturbance observed fell between Class 1 and Class 2; low-moderate disturbance. Such areas are not quite detrimentally disturbed/compacted but have strong visual indicators of soil disturbance. These areas could be called recovering detrimentally disturbed areas. Disturbance class 2 could be best described as a 50-year old skid trail with duff over a very thin A horizon.

The project area units were extremely varied in size: from about 3 to more than 100 acres. To cover these units we varied the number of points. A target of 60 points was classified for all units greater than 25 acres but less than 100 acres. For units less than 25 acres, we took about 40 points but added more if higher-than-average rates of disturbance were found (i.e. more than 1 or 2 points) to increase our sampling density. For the units greater than 100 acres, we increased our points and tried to arrange transects to sample as many portions of the units as possible. In units where we found higher than expected levels of disturbance, we took more points.

Our field work also included Coarse Woody Debris (LWD) survey. These were taken every 5-7 points during the disturbance survey. Our points were 10 paces apart which measures about 50 feet. We counted all LWD larger than 3 inches and tracked it on our data sheets according to diameter size.

In addition, we tracked our paths with a GPS, took unit notes to describe what we saw, and took representative photos of all units. The tracks, start/stop points, and any significant features were tracked with the GPS and uploaded into GIS. This info will be compiled into a geodatabase as part of the analysis and project file. The notes are to capture the nature and distribution of the disturbance found in the units.

Affected Environment

The Salt Project area is located in the Rattlesnake Creek (M261Au) Ecological Subsection of the Klamath Mountains Ecological Section (M261A) of northern California (Cleland et al., 2007) (Jasso, 2007) (Elevation ranges from about 3500 to 5800 feet. The area is primarily vegetated with a mix of conifers with hardwood species occurring on steep, rocky slopes. This project area is dominated by intensely faulted Paleozoic metavolcanic and metasedimentary rocks and serpentized peridotite. Mass wasting and fluvial erosion are the main geomorphic processes. The slopes are gentle, ranging from 20 to 40 percent in the analysis area. This area is mountainous with rounded ridges, steep sides and narrow canyons. Little surface water exists as runoff is rapid and the soils are well drained.

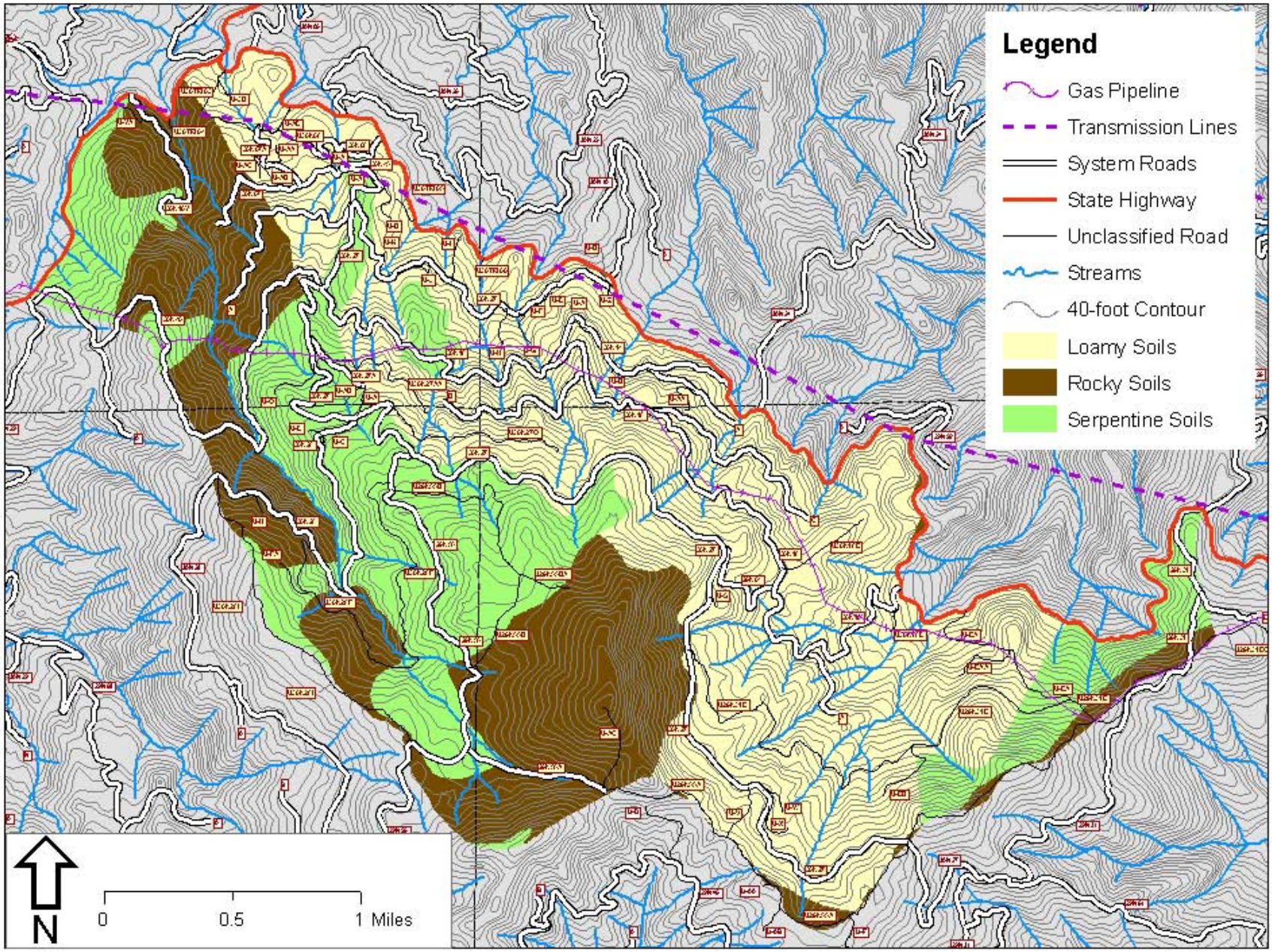

Figure 1. Salt project analysis area soils.

The climate of the Salt project area is characterized by cool, wet winters and warm, dry summers. Average annual precipitation is 40 to 60 inches of mostly rain with little snow.

The soils in the project area are generally shallow to moderately deep with high amounts of rock fragments (Table 1). Serpentine-derived soils exist in the project area. A few of the soils have significant amount of clay (Beaughton and Dubakella). Most of the project area is a loamy textured soil with few rock fragments that formed on dormant landslides. Several soils are shallow to bedrock.

Soil fertility in the Salt project area is moderately high to low depending upon the parent material and available water holding capacity. Generally, deeper, finer-textured soils with high available water-holding capacities (AWC) have the highest soil fertilities. Marpa, and Holland, have the highest soil fertility while Neuns soils have moderate fertility. In general, most timber soils the parent material has low fertility and most nutrients are recycled from decomposing roots and surface organics that gets incorporated into the soil. It is important to note the critical role surface organics and organic compounds have in soil fertility.

Table 1. Physical properties of Salt Analysis Area soils

Soil Name	Texture	Rock fragments (%)	Parent Material	Depth*	Acres	% of analysis area
Beaughton Family	Clayey-skeletal	25-60	Serpentine	Shallow	561	13
Deadwood Family	Loamy-Skeletal	50-85	metasediments	Shallow	0.2	<<1
Dubakella Family	Clayey-skeletal	30-60	Peridotite	Moderate	83	2
Grell Family	Loamy-Skeletal	40-60	Serpentine	Shallow	23	1
Goulding Family	Loamy-Skeletal	45-75	metasediments	Shallow	inclusion	
Holland Family	Fine-loamy	10 -35	Metasediments/ dormant landslides	Moderate	1,693	40
Hugo Family	Fine-Loamy	10-30	metasediments	Deep	inclusion	
Marpa Family	Loamy-Skeletal	25-55	metasediments	Moderate	381	9
Neuns Family	Loamy-Skeletal	40-65	metasediments	Moderate	657	15
Neuns Family, deep	Loamy-Skeletal	40-65	metasediments	Deep	327	8
Rock Outcrop	Massive Rock	N/A	metasediments	Very Shallow	57	1
Rock Outcrop, ultramafic	Massive Rock	N/A	Serpentine	Very Shallow	42	1
Weitchpec Family	Loamy-Skeletal	40-55	Peridotite	Moderate	453	11
				Total	4279	

Depth classes are: Very Shallow - <10 inches, Shallow - 10-20 inches, Moderate - 20-40 inches, Deep - 40-60 inches

Fine-textured soils with few rock fragments have a high compaction hazard. Generally, soils with coarse fragments greater than 40% are better equipped to resist compaction from machine use. The fragments act as a skeleton and protect the more compressible particles in the soil. Holland soils, for example, have a severe compaction rating due to fine texture and lack of rock fragments. Coarse fragments can also act as soil cover, protecting soils from erosion.

Even more important than soil texture in predicting risk of compaction is soil moisture. Dry soils are less likely to compact and have a lower risk of compaction than moist soils (Welke and Fyles. 2005). Under moist conditions, even course soils can compact.

Organic component of soil

Organic matter content plays a large role in the storage and release of plant available nutrients. Organic matter ranges is size and distribution from small-particles in soil (SOC) to soil surface litter, to large decaying logs. The logs are called large woody debris (LWD).

Disturbances to the organic matter content in mineral soils can have negative effects on soil nutrient status. The soil productivity of a site will remain intact as long as the surface horizons are not highly disturbed or displaced. This means retaining existing duff and minimizing displacement of the soil surface. Long term study plots demonstrate a significant reduction in soil carbon and plant-available nutrients when the forest floor (organic mat) is removed (Powers et al., 2005). When the surface organics are removed fine textured soils can lose up to 13 percent porosity due to compaction (Gomez et al., 2002). Gomez et al.'s study demonstrates the importance of duff or litter cover in mitigating compaction.

LWD functions as habitat for vertebrates and invertebrates and not micronutrient banks. In addition to terrestrial habitat, LWD is beneficial for continued soil productivity by ameliorating the site after forest clearing. The wood provides microsites for microbial activity, retains carbon on site, and may moderate soil moisture (Brown et al., 2003).

Serpentine soils in the project area

Serpentine geology is found in the project area. The soils from serpentine rock have several limitations for management. Serpentine soils can have high levels of asbestos that pose health risks form dust inhalation. Serpentine soils have low fertility due to a low Ca/Mg ratio. These areas can be barren, with sparse vegetative cover and shallow soils (USFS, 2004). Serpentine soils even with high rates of rock fragments have a severe risk of compaction due to clayey texture and soft rock structure. Most serpentine soils that have low CA/Mg ratio do not support conifer vegetation.

Existing condition for soils

Much of the Salt watershed has been managed in the past 50 years. The forests have been selectively harvested, mostly targeting the profitable wood species—mostly Sugar Pine and Ponderosa Pine. Most of the timber was removed by ground-based yarding systems, usually a cat or arch-skidders. A dense skid trail and unclassified road network exists throughout the Salt Analysis area. A portion of the project area was managed in the 1980s and is now in pine plantations.

The Post Creek grazing allotment occurs on about half of the Salt project area. Some evidence of grazing was noted, especially in the meadows, in units 7 and 2A. Detrimental soil impacts from grazing were not observed.

Little past erosion was detected in the project area due to a continuous duff layer on all soils. Also, there was high soil cover from vegetation or rocks (Appendices C and D). All surveyed units had at least 90% cover with most having close to 100% cover. Where the surface organics are missing, the coarse fragments in the soil are keeping erosion rates very low. Some road segments were actively eroding and there were ruts and gulleys in a few areas. Many of these roads are unclassified roads. Please refer to the hydrology/watershed resource report for further discussion of roads.

Please refer to hydrology resource report for equivalent roaded area (ERA) calculations and erosion modeling.

The average disturbance and decrease in total porosity was determined in the field. Forty-seven percent of the Salt area is in a disturbed state and the rest of the area is undisturbed (Table 2) (Rust, 2007). Most of the proposed units have less than 5% detrimental soil disturbance. The average is 3%. However, unit 13

with 10% and unit 21 with slightly over 5% detrimental disturbance are notable exceptions. Unit 13 disturbance is high due to several benched skid trails/old temp roads that are not recovered. While the skid trails in the project area units are noticeable, the compaction has been relieved since harvest. Only decreases in porosity of 10% or greater are considered detrimental soil compaction. Therefore, only the roads would be considered as detrimentally compacted.

Table 2: Average Disturbance and porosity for Salt Project Area

Disturbance Class	Percent Project Area	Porosity Average %	Porosity % change from undisturbed	Moisture %
Undisturbed	53	52	0	14.6
Disturbed	27	51	2	15.2
Skid trails	17	51	2	15.4
Roads	3	45	14	14.8
Total Disturbed	47			

From: Rust, 2007

Existing soil cover in selected proposed units is very high (Appendix D). Duff thickness ranged from 1 to 3 inches. Results of the fuel cover transects indicate that the dominant cover is the 1 to 3 inch and the 3 to 20 inch class of woody material (Rust, 2007). Large woody debris (LWD) ranged from 5 to 10 trees/ac for mixed conifer stands, from 3 to 8 trees/ac for tree/brush stands, and 1 to 5 logs/ac for brush areas (Rust 2007). This meets the R-5 SQS (Appendix D).

Methodology for Analysis

Soil resources on the project area have been reviewed using soil survey data and slope data in GIS, aerial photos, and field reconnaissance. Soil survey data has been used for project scale analysis and for describing the project area. A selection of proposed intermediate thinning, Green Tree Retention, and plantation thin units and road locations were field reviewed by the soil scientist to identify areas where soil productivity may be affected by the proposed activities. Best Management Practices (BMPs) and resource protection measures for soil protection in harvest units and along road segments are based on field data. Effects analyses were based on the proposed silvicultural prescriptions and fuel treatments.

The analysis area, or bounding area, for direct, indirect, and cumulative effects for the soil resource includes the proposed harvest units. This is the area that is expected to be directly impacted by any silvicultural or fuel reduction activities. The Salt Analysis Area (Figure 1) is used to qualitatively discuss the past activities outside of proposed treatment units. Please see the hydrology resource report for cumulative watershed effects.

Effects to soils from roads are long-term, generally defined as more than 50 years. Most activities from thinning have different recovery rates. Compaction of the Salt project area soils lasts approximately 50 years during which inputs from plant roots, other organic inputs or, physical weathering relieves the compaction. Erosion recovery is three to five years and fertility is one to two years.

The following units of measure will be used to describe the differences between Alternatives.

- Erosion Hazard Rating (EHR) a measure of the risk of accelerated erosion
- Percent detrimental soil conditions from thinning and fuel operations, including skid trails, temp roads, treatment units, etc post activity. Number of units that have a high risk of exceeding SQS
- Miles of Temporary road constructed

- Degree of Influence on Soil Productivity, are based on monitoring information, literature and professional experience. These are defined as follows:
    - **Negligible:** Soil resources would not be affected or the change would be so small that it would not be of any measurable of any perceptible consequence. Negligible, as defined here, includes no effect. Erosion rates would remain normal (1-2 ac/ton/year). No detrimental soil disturbance is expected.
    - **Minor:** Effects to soil resources would be measurable, although the changes would be small, likely short-term, the effects localized. No mitigation measures are needed. Erosion rates would be at natural levels to slightly accelerated in a few, discreet areas. Moderate compaction/displacement would exist but it would not be detrimental or continuous. Soil cover would remain high—preventing erosion and maintaining fertility. Soils would meet R-5 SQS in all units. Most of the skid trails/tractor operation would occur on slopes less than 35%.
    - **Moderate:** Effects to Soil resources would be measurable and long-term but the effects would be local. Mitigation would be necessary and would be successful. There would be accelerated erosion, some detrimental compaction, and/or noticeable loss of vital soil fertility. The effect may be long-term but soil productivity would still meet standards through most of the units through mitigation (detrimental soil disturbance would be lower than 15%). There would be tractor operation on small areas greater than 35 percent slope.
    - **Major:** Effects to Soil resources would be measurable with substantial consequences. Mitigation measures would be necessary and their success would not be guaranteed. Erosion will be accelerated beyond natural conditions. Detrimental disturbance as compaction would exceed R-5 standards on over 15 percent of the area. Soil fertility would be severely limited (little soil cover, loss of organics, no LWD). The plant community is different in large areas from what is expected. There would be several areas where tractors are expected to operate on sustained slopes greater than 35%

Assumptions

Post thinning and fuel treatments activities should have at least 50% of soil cover. Operations should minimize disturbance to existing duff layer where possible. Soil cover from duff, vegetation or surface rock fragments should be maintained to keep erosion rates at natural levels. Skid trails and roads will be waterbarred, slashed or seeded to prevent accelerated erosion. Roads, landings or other transportation features will be treated and upgraded to meet BMP and water quality standards.

The aerial extent for non-productive dedicated uses such as trails and landings will be 15 percent of an activity area (generally a unit). Porosity (an expression of compaction) shall not decrease by 10% over background levels through unit (ST-LMP, Appendix O, Soil Quality Standards).

The organic mat (duff layer) should be preserved as much as operation will allow. Minimizing damage to this layer will moderate soil temperatures, nutrient processes, soil biological health, and supports the long term soil productivity. Retention of at least 50 percent soil cover in the form of slash, duff, and litter will meet the Forest Plan tonnage requirement of at least 5 tons/acre. Also, the duff mitigates compressive forces in the soil. There will be at least 5 pieces of LWD per acre left to meet SQS. Masticated or chipped material will be less than about 3 inches (7.5 cm) to prevent detrimental soil burning.

New tractor disturbance is estimated at 7% as based on Shasta-Trinity Soil Monitoring (Rust, 2008). There will be some, up to 5% overlap, between existing disturbance and new disturbance. Detrimental soil conditions are calculated for the individual harvest units. Detrimental soil conditions incurred by proposed harvest activities are calculated by harvest method: 7 percent for tractor harvest (Rust, 2008) on

slopes less than 35%, 20 percent or tractor harvest on sustained slopes greater than 40%, and 3% for helicopter).

The effect of management on soil recovery is dependent on soil type, climate, moisture, cover and time. Depending on what effect is measured (erosion or compaction or fertility) will determine recovery rates. Table 3 shows that there is some short term increases in erosion but over a 3 to 5 year span those rates drop to background (due to falling leaves, braches, needles, grass and forbs). Monitoring by the Shasta-Trinity National Forest (Rust, 2008) revealed that soils with high clay content (Holland and Hugo) can remain compacted for up to 40 years. Soils with less clay and more rock fragments recover sooner (Marpa and Neuns). Reduced duff and dead woody material reduce fertility in the sort-term but recover quickly. Also, residual trees respond with increased growth, root mass, soil organic matter and an overall increase of soil fertility when released.

Table 3. Recovery Rates for Project Activity (understory thinning) Soils

Soil Type	Erosion	Compaction	Fertility
Holland	3-5 years	30-40 years	1-2 years
Hugo	3-5 years	30-40 years	1-2 years
Marpa	3-5 years	15-30 years	1-2 years
Neuns	3-5 years	5-10 years	1-2 years

Environmental Consequences

Erosion risk for all units is low or moderate with the exceptions of unit 18 and the shaded fuel break (unit 45). By implementing all resource protection measures, BMPs, and standard contract clauses all units are expected to meet R-5 soil quality standards. There should be less than 15 percent of any unit in skid trails, adequate cover should minimize erosion, added slash and maintenance of the duff layer should maintain soil biological process, soil fertility, and ultimately soil productivity.

Mitigation and Monitoring

All unstable geologies, namely serpentines, were avoided in project design to maintain soil stability and limit major problems when managing these areas (Jasso, 2007).

The following resource protection measures are included and should apply (all resource protection measures can be found in Chapter 2):

- Maintain an average of 5 tons of logs per acre with a preference to have 4 to 6 logs per acre at the largest diameter available
- No full bench skid trails would be constructed. Skid trails, when possible, would be located on ridge tops, flat benches, or existing skid trails to minimize soil displacement and enhance drainage.
- For all ground –based operations the distance between skid trails will be a minimum of 100 feet measured center to center, except when converging. All material would be skidded with the leading end clear of the ground.
- Excess activity created slash and existing surface fuels can be machine piled or masticated on slopes less than 35% and hand piled or lopped and scattered on slopes greater than 35%. Applies to units 4, 5, 11, 12, 17, 18, 20, 21, 22, 32, 33A, 33B, 33C, 36, 37, 40, 45.
- Tracked Machines are generally restricted to slopes less than 35%. Endlining will be used in those areas where skid trails may exceed 35%. Skid trails located on small inclusions of steep

areas exceeding 35% would be covered with woody material larger than 9 inches to divert flow off the trail. Mechanical skidding equipment is restricted to slash covered primary skid trails where slopes are greater than 35%.

- When heavy equipment such as a harvester is used off a designated skid trail in the specified units (due to fine textured soil), limit the number of passes to 1 and no more than 2 passes over the same piece of ground. Applies to units 9A, 14, 17, 18, 25A, 25B, 25C, 25E, 30A, 30B, 26, and 40.
- Dedicate no more than 15% of a harvest unit to primary skid trails and landings.
- Decommissioning of roads (13.8 miles) will consist of removing culverts, ripping road surfaces, out-sloping to maintain hillslope hydrology as well as other measures to meet site-specific needs. The goal is to control surface runoff and to prevent or minimize erosion and mass failure. Seeding as needed with native grass seed and non-persistent cereal grains and mulching on selected roads.
- Minimize soil erosion by mulching primary skid trails with straw or fine slash (achieve 50 percent or more cover). Install waterbars at major breaks in slope and regular intervals along the trail.
- At the end of project activities, a layer of ground cover should occur over at least 50% of the activity area.
- Rip (with winged subsoil to 18 inches deep) and mulch all temporary roads, skid roads and landings as identified by the project soil scientist.
- Reuse existing primary skid trails and landings whenever possible.
- Slash and existing surface fuels must be hand piled or lopped and scattered on slopes greater than 35 percent.
- Ground-based mechanical equipment will only operate in these specified units (fine-textured soils, non-rocky) when the soils are dry down to 8 inches (from June 01 to September 30, Wet weather operating standards). Units 2A, 2B, 2C, 6, 7, 9A, 9B, 10, 11, 13, 14, 17, 18, 25A, 25B, 25C, 25D, 25E, 26, 30A, 30B, 40.
- Masticated material will be kept to a depth of 3 inches or less OR burning, if planned, will occur in the spring (moist soil condition). Units where biomass will not be removed 4, 5, 11, 12, 17, 18, 20, 21, 22, 32, 33A, 33B, 33C, 36, 37, 40, 45.

Desired Condition for all units

Soil productivity is retained in all treatment units.

Alternative 1 – No Action

Direct Effects

There are not any direct effects to soil productivity in Alternative 1.

Indirect Effects

All roads would remain open to traffic and remain in place. No rehabilitation would occur. Erosion rates would be low on all areas. For a discussion of roads and their impacts please see the watershed report.

Skid trails and the moderately compacted areas would continue to improve and recover.

Soil biological functions would continue. The existing surface organics would continue to decompose and contribute to soil organic matter and duff. Topsoil would build from the organic matter.

This alternative would not treat excessive fuel accumulation. Erosion rates would be excessive if a major fire occurred, thus necessitating the need a for fuel reduction program in these areas to protect soil resources.

Cumulative Effects

Roads in the project area will be rehabilitated in a future EA. Any future entries into these units would disturbance to an existing average of 3 percent detrimental soil conditions.

Alternative 2 – Proposed action

Direct Effects

The resource protection measures, BMPs, and contract clauses all serve to reduce erosion. Erosion rates may be higher in localized areas during operation but then return to natural levels post activity. Past BMP monitoring has demonstrated that these practices have been successful. The Shasta-Trinity has a good record of BMP implementation (USFS, 2004). By leaving at least 50% canopy cover and at least 50% soil cover, the maximum erosion hazard is moderate for all intermediate thin (INT) units. The two green tree retention harvest (GTR) units and one of the shelterwood harvest (SW) units have a moderate erosion risk rating (units 37, 40, 17). SW unit 18 has a moderate-high risk of accelerated erosion due to high amounts of rock outcrop and steep slopes (Table 4), however, the design criteria to restrict mechanical skidding equipment to slash covered primary skid trails where slopes in areas greater than 35% would reduce potential impacts.

The shaded fuel brake also has a moderate-high risk of accelerated erosion, though little actual erosion was observed in the field. The removal of fuels and less than 50% canopy cover all contribute to accelerated erosion risk. The slope distance are short and following BMPs during operations, and resource protection measures minimize the hazard.

Erosion risk on the plantation thin units depends largely on the slope and thinning method. Generally, hand falling is less likely to disturb enough soil and existing ground cover to increase erosion on all slopes. Mechanized thinning on slopes less than 20% have a low erosion risk, slopes 20-35 percent have a moderate risk and slopes greater than 35% with mechanized thinning have the highest risk of accelerated erosion. However, resource protection measures do not allow mechanical harvesting or treatment on slopes greater than 35 percent.

Table 4 Alternative 2 Direct effects summary

Treatment	Erosion Hazard	Compaction
GTR with and without slash removal	Moderate	7% additional detrimental disturbance from tractor harvesting, generally limited to skid trails. All should meet SQS
Shelterwood with and without slash treatment	17 is moderate. 18 is moderate-high	7% additional detrimental disturbance from tractor harvesting, generally limited to skid trails. All should meet SQS
INT with and without fuel treatment	Generally moderate except for 2A, 4, 7, 33B and 36 which are low.	7% detrimental disturbance from tractor harvesting, generally limited to skid trails. All units should meet SQS. Unit 13 has a moderate risk of exceeding SQS.

Treatment	Erosion Hazard	Compaction
INT Helicopter (Unit 32)	Minor	3% detrimental disturbance from helicopter yarding. Should meet SQS
Fuel treatments	Unit 45 is moderate high	Should meet SQS.
Plantation thin	Varies by slope by slope: less than 20% is low, 20-35% is moderate, 35% plus is high. Handfalling hazard is low across all slopes	Low risk especially since mechanized equipment is limited to slopes less than 35%. Handfalling has the lowest risk of exceeding SQS.

The effects of fuel treatments on soils vary by method. Generally, hand methods have less of an impact on soils than mechanical ones (Table 5). Keeping chipped or masticated material thickness to 3 inches or less and burning with soil moisture is at least 20% will minimize detrimental burning of soils. Soil can be detrimentally burned if there is a thick matt of masticated material over the soil. This is detrimental heating and can expose a soil to accelerated erosion and loss of fertility. The potential for severe biological damage from soil heating during fire exists following mastication, particularly in dry soil with mulch depths of 7.5 cm (about 3 inches) or greater. Dense pre-mastication vegetation could create mulch thickness dense enough to surpass lethal soil temperatures (Busse et al., 2005). Lethal soil heating is generally governed by soil moisture, soil depth, and fuel heat load but not necessarily soil texture. Soil moistures of 20% were sufficient to inhibit the progression of surface soil temperatures (Busse et al. 2006).

Approximately 0.3 miles of temporary road would be constructed which will be rehabilitated after harvest activities. Very short segments of road are needed to access 4 different units (0.05 miles for Unit 5; 0.07 miles for Unit 9A; 0.03 miles for Unit 11 and 0.15 miles for unit 33A). Assuming a 12 foot road width, the temporary roads would result in 0.4 acres of detrimental soil disturbance spread out over the 4 different units. Each of these units would still meet SQS for detrimental soil disturbance.

There would be a moderate degree of influence on soil productivity due to sections of tractor harvest over 35%. While most are excluded by design criteria, these areas have higher rates of displacement than on slopes less than 35 percent gradient.

Table 5: Fuel treatments and their qualitative effect on soils

Treatment	Effects on Soil
Mastication	Fuel rearrangement, increased soil cover, temperature, moisture and microbe activity, possible short-term (less than 5 years) C/N imbalance if too much incorporation.
Lop & Scatter	Scatters 3 to 10 in material, provides soil cover, breaks down rapidly into fine litter and slow (greater than 10 years) incorporation.
Hand pile	Similar to lop-and-scatter except concentrated, decomposes more slowly (greater than 10 years), concentrations can burn hot but are not continuous.
Jackpot	Concentrated areas of fuel consumed can be hot but are limited on the landscape are mosaic and do not increase overland erosion above natural rates.
Tractor Pile	The highest effects to soil productivity due to mechanical treatment. Topsoil mixed in with slash, moderate compaction (10 to 20 years) and loss of topsoil if not done properly with brush rakes and good operator.

Indirect Effects

There is a poor link between physical indicators like compaction and biological indicators like soil carbon of soil health (Shestak and Busse, 2005). Type and distribution of organic matter is a better metric. The surface organics and soil organic carbon (SOC) have been linked to long-term soil productivity. Complete

removal of organic matter, mostly the loss of the duff/forest floor, has led to declines in soil productivity and reduced nitrogen availability (Powers et al., 2005). This pulse removal can be felt at least 10 years after activity. Partial removal of biomass may reduce the soil organic carbon and nutrient availability for a short time, but canopy retention and growth inputs from fine roots shorten the duration of effects. Biological integrity of the site should be maintained by the required retention of duff, litter, and LWD.

Cumulative Effects

It takes about 50 years for compaction to be relieved in these soils as judged from recovered past entries. When rotations are closer than this, compaction rates in fine-textured soils will remain high and the risk of exceeding SQS in an entry 10-20 years is elevated. Generally most units have between 3 and 5 percent existing detrimental disturbance as detrimental compaction. With the added 13% from tractor, considering overlap as most of the existing disturbance is in skid trails that would be reused, the detrimental disturbance will be at or below 15%.

Mechanical thinning of plantations adds some detrimental disturbance as compaction and displacement to an already detrimentally disturbed area. Continuing to enter these stands at regular intervals may increase the compaction each time without adequate time for the soil to recover. However, most data indicate that operating on dry soil on these low-to moderately compacted areas results in moderate compaction that is not root-limiting (Rust, 2008).

Alternative 3

Direct Effects

Direct effects are similar to alternative 2 (Table 6). Alternative 3 does not treat GTR units. Thus, units 37 and 40 will not be treated and will remain as they are now: not actively eroding and with about 3% detrimental soil conditions. No temporary roads are proposed for alternative 3.

Table 6 Alternative 3 Direct effects summary

Treatment	Erosion Hazard	Compaction
Shelterwood with and without slash treatment	17 is moderate. 18 is moderate-high	7% additional detrimental disturbance from tractor harvesting, generally limited to skid trails. All should meet SQS
INT with and without fuel treatment	Generally moderate except for 2A, 4, 7, 33B and 36 which are low.	7% detrimental disturbance from tractor harvesting, generally limited to skid trails. All units should meet SQS. Unit 13 has a moderate risk of exceeding SQS.
INT Helicopter (Unit 32)	Minor	3% detrimental disturbance from helicopter yarding. Should meet SQS
Fuel treatments	Unit 45 is moderate high	Should meet SQS
Plantation thin	Varies by slope by slope: less than 20% is low, 20-35% is moderate, 35% plus is high. Handfalling hazard is low across all slopes	Should meet SQS since mechanized equipment is limited to slopes less than 35%. Handfalling has the lowest risk of exceeding SQS.

Indirect Effects

Carbon interactions would be similar for both Alternative 2 and 3.

Temporary roads generally have a 12 foot wide foot print, so the disturbed area from 0.3 miles of temporary road would be 0.4 acres (0.3 miles X 5280 feet/mile X 12 feet wide = 19,008 sq. feet = 0.4

acres). The foot print width for a main skid road needed to remove biomass would be approximately 18 feet wide, which would disturb approximately 0.6 acres (0.3 miles X 5280 feet/mile X 18 feet wide = 28,512 sq. feet = 0.6 acres). Though most of the effects would be mitigated and thresholds would not be exceeded, there would be slightly higher, though insignificant, amount of detrimental soil compaction and displacement in Units 5, 9A, 11, and 33A due to greater skidding disturbance in Alternative 3 compared to Alternative 2.

Cumulative Effects

Similar to Alt 2. (Table 7)

Since this alternative does not treat units 37 and 40 there would be no cumulative effect to soils in these units. Because less material will be removed in all of the other treatment units (retaining 60% canopy vs. 50% in alternative 2, stands may be entered on a shorter rotation than in Alternative 2, meaning the cumulative impacts to soils may be higher. Increasing the frequency of return does not allow soils to recover adequately (compaction takes about 50 years to recover).

Table 7. Comparison of alternatives for soil resources

Measure	Alt 1	Alt 2	Alt 3
Generalized erosion risk	Low	Moderate	Moderate
Cumulative aerial extent of Soil compaction/sqs	3%	15% maximum	15% maximum
Temp roads	0	0.3	0
Degree of influence on soil productivity*	Negligible	Moderate**	Moderate**

* for description of each unit please see appendices C and E.
**Moderate due to tractor yarding on areas greater than 35 percent slope

Compliance with the Forest Plan and Other Regulatory Direction

By implementing the resource protection measures, BMPs and any other mitigation measures, the proposed activities will comply with the Shasta-Trinity Forest plan and handbook direction.

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Appendix A. Soil Interpretations

Table A-1. Soil Interpretations of Salt Project Area Soils.

Series	AWC* (in/in)	Drain.	Burn Hazard	Compaction Hazard	Hydro Group
Beaughton	.10-.14	W	Moderate	High	D
Deadwood	.07-.09	W	High	Moderate	D
Dubakella	.12-.14	W	Moderate	Moderate	C
Grell	0.8-2.3	W	Moderate	Moderate	C
Holland	.13-.15	W	Low	Severe	B
Marpa	.12-.14	W	Low	High	B
Neuns	.07-.09	W	40-65	Moderate	C
Rock Outcrop	0	EW	High	N/A	D
Weitchpec	.09-.13	W	Moderate-High	Moderate	B

* Available Waterholding Capacity (AWC)

Appendix B

The EHR was developed to assess the potential risk of a given soil to erode (R-5 FSH 2505.22). The EHR system is designed to assess the relative risk of accelerated sheet and rill erosion. This rating system is based on soil texture, depth, clay percent, infiltration, rock fragments, surface cover, slope, and climate. Risk ratings range from low to very high. Moderate ratings mean that accelerated erosion is likely to occur in most years and water quality impacts may occur, mitigation may be applied in certain cases. High to very high EHR ratings mean that accelerated erosion is likely to occur in most years and that erosion control measures should be evaluated.

Table B-1. EHR for Salt Project area soils

Soil (% Slope) Treatment	Texture	Aggregate Adjustment	Erodibility	Climate (1.8-2.2)	Water Movement	Runoff	Uniform Slope Length	Runoff Production	Runoff Production Rating	Slope %	Runoff Energy Rating	Soil Cover %	Soil Cover Rating	Erosion Hazard Rating	Rating
Beaughton															
(20 - 40%) bare	3	0	3	3	3	0	3	9	3.00	30	0.3	0-10	5	13.5	High
current	3	0	3	3	3	0	3	9	3.00	30	0.3	(90-100)	1	2.7	Low
treatment	3	0	3	3	3	0	3	9	3.00	30	0.3	(50-70)	2	5.4	Moderate
(50 - 80%) bare	3	0	3	3	3	0	3	9	3.00	65	0.65	0-10	5	29.3	Very High
current	3	0	3	3	3	0	3	9	3.00	65	0.65	(90-100)	1	5.9	Low
treatment	3	0	3	3	3	0	3	9	3.00	65	0.65	(50-70)	2	11.7	Moderate
Deadwood															
(40 - 60%) bare	3	-1	2	3	3	0	3	9	3.00	50	0.5	0-10	5	15.0	High
current	3	-1	2	3	3	0	3	9	3.00	50	0.5	(90-100)	1	3.0	Low
treatment	3	-1	2	3	3	0	3	9	3.00	50	0.5	(50-70)	2	6.0	Moderate
Dubakella															
(20 - 40%) bare	2	-1	1	3	2	0	3	8	2.67	30	0.3	0-10	5	4.0	Moderate
current	2	-1	1	3	2	0	3	8	2.67	30	0.3	(90-100)	1	0.8	Low
treatment	2	-1	1	3	2	0	3	8	2.67	30	0.3	(50-70)	2	1.6	Low

Soil (% Slope) Treatment	Texture	Aggregate Adjustment	Erodibility	Climate (1.8-2.2)	Water Movement	Runoff	Uniform Slope Length	Runoff Production	Runoff Production Rating	Slope %	Runoff Energy Rating	Soil Cover %	Soil Cover Rating	Erosion Hazard Rating	Rating
Grell															
(20 - 40%) bare	3	-1	2	3	3	0	3	9	3.00	30	0.3	0-10	5	9.0	Moderate
current	3	-1	2	3	3	0	3	9	3.00	30	0.3	(90-100)	1	1.8	Low
treatment	3	-1	2	3	3	0	3	9	3.00	30	0.3	(50-70)	2	3.6	Low
Holland															
(20 - 40%) bare	3	0	3	3	2	0	3	8	2.67	30	0.3	0-10	5	12.0	Moderate
current	3	0	3	3	2	0	3	8	2.67	30	0.3	(90-100)	1	2.4	Low
treatment	3	0	3	3	2	0	3	8	2.67	30	0.3	(50-70)	2	4.8	Moderate
(40 - 60%) bare	3	0	3	3	2	0	3	8	2.67	50	0.5	0-10	5	20.0	High
current	3	0	3	3	2	0	3	8	2.67	50	0.5	(90-100)	1	4.0	Moderate
treatment	3	0	3	3	2	0	3	8	2.67	50	0.5	(50-70)	2	8.0	Moderate
Marpa															
(20 - 40%) bare	3	-1	2	3	2	0	3	8	2.67	30	0.3	0-10	5	8.0	Moderate
current	3	-1	2	3	2	0	3	8	2.67	30	0.3	(90-100)	1	1.6	Low
treatment	3	-1	2	3	2	0	3	8	2.67	30	0.3	(50-70)	2	3.2	Low
Nenus															
(20 - 40%) bare	3	-1	2	3	2	0	3	8	2.67	30	0.3	0-10	5	8.0	Moderate
current	3	-1	2	3	2	0	3	8	2.67	30	0.3	(90-100)	1	1.6	Low
treatment	3	-1	2	3	2	0	3	8	2.67	30	0.3	(50-70)	2	3.2	Low
(40 - 60%) bare	3	-1	2	3	2	0	3	8	2.67	50	0.5	0-10	5	13.3	High
current	3	-1	2	3	2	0	3	8	2.67	50	0.5	(90-100)	1	2.7	Low
treatment	3	-1	2	3	2	0	3	8	2.67	50	0.5	(50-70)	2	5.3	Moderate

Soil (% Slope) Treatment	Texture	Aggregate Adjustment	Erodibility	Climate (1.8-2.2)	Water Movement	Runoff	Uniform Slope Length	Runoff Production	Runoff Production Rating	Slope %	Runoff Energy Rating	Soil Cover %	Soil Cover Rating	Erosion Hazard Rating	Rating
(60 - 80%) bare	3	-1	2	3	2	0	3	8	2.67	70	0.7	0-10	5	18.7	High
current	3	-1	2	3	2	0	3	8	2.67	70	0.7	(90-100)	1	3.7	Low
treatment	3	-1	2	3	2	0	3	8	2.67	70	0.7	(50-70)	2	7.5	Moderate
Nenus, Deep															
(20 - 40%) bare	3	-1	2	3	1	0	3	7	2.33	30	0.3	0-10	5	7.0	Moderate
current	3	-1	2	3	1	0	3	7	2.33	30	0.3	(90-100)	1	1.4	Low
treatment	3	-1	2	3	1	0	3	7	2.33	30	0.3	(50-70)	2	2.8	Low
Weitchpec															
(20 - 40%) bare	2	-1	1	3	3	0	3	9	3.00	30	0.3	0-10	5	4.5	Moderate
current	2	-1	1	3	3	0	3	9	3.00	30	0.3	(90-100)	1	0.9	Low
treatment	2	-1	1	3	3	0	3	9	3.00	30	0.3	(50-70)	2	1.8	Low
(40 - 60%) bare	2	-1	1	3	3	0	3	9	3.00	50	0.5	0-10	5	7.5	Moderate
current	2	-1	1	3	3	0	3	9	3.00	50	0.5	(90-100)	1	1.5	Low
treatment	2	-1	1	3	3	0	3	9	3.00	50	0.5	(50-70)	2	3.0	Low

Appendix C. Summary of soil effects by unit

Table C-1. Summary of Soil Effects by proposed Salt unit

Unit #	Acres	erosion risk, max	Slope	Current Detrimental Disturbance	Projected Additional Detrimental Disturbance	Risk of Exceeding R5 Disturbance Threshold	Degree of influence
Salt 1	87	Moderate	10-50%	2.5%	7.00%	Moderate	Moderate
Salt 2a	10	Low	10-20%	2.0%	7.00%	Low	Minor
Salt 2b	50	Moderate	10-40%	5.0%	7.00%	Low	Moderate-Low
Salt 2c	95	Moderate	15-60%	2.2%	7.00%	Low	Moderate
Salt 3	12	Moderate	10-50%	3.3%	7.00%	Low	Moderate
Salt 4	8	Low	15-25%	0.0%	7.00%	Low	Minor
Salt 5	19	Moderate	10-50%	1.7%	7.00%	Low	Moderate
Salt 7	21	Low	10-15%	5.0%	7.00%	Low	Moderate-Low
Salt 9A	12	Moderate	10-30%	3.3%	7.00%	Low	Minor
Salt 9B	17	Moderate	10-30%	3.3%	7.00%	Low	Minor
Salt 10	24	Moderate	25-40%	5.0%	7.00%	Low	Moderate
Salt 11	17	Moderate	25-45%	5.0%	7.00%	Low	Moderate-Low
Salt 12	36	Moderate	15-40%	5.0%	7.00%	Low	Moderate
Salt 13	9	Moderate	20-30%	10.0%	7.00%	Moderate	Moderate
Salt 14	19	Moderate	30-60%	5.0%	7.00%	Low	Moderate
Salt 17	15	Moderate	20-30%	0.0%	7.00%	Low	Minor
Salt 18	16	Moderate-High	15-50%	2.5%	7.00%	Low	Moderate-high
Salt 20	19	Moderate	20-40%	3.0%	7.00%	Low	Moderate
Salt 21	19	Moderate	15-30%	5.2%	7.00%	Low	Moderate
Salt 22	76	Moderate	10-40%	1.3%	7.00%	Low	Moderate
Salt 25A	12	Moderate	20-45%	1.7%	7.00%	Low	Moderate-Low
Salt 25B	5	Moderate	10-25%	3.3%	7.00%	Low	Minor
Salt 25C	4	Moderate	10-35%	0.0%	7.00%	Low	Minor
Salt 25D	14	Moderate	45-50%	0.0%	7.00%	Low	Minor
Salt 25E	34	Moderate	5-45%	3.3%	7.00%	Low	Moderate
Salt 26	17	Moderate	20-50%	3.3%	7.00%	Low	Moderate
Salt 30A	17	Moderate	10-35%	3.0%	7.00%	Low	Moderate
Salt 30B	13	Moderate	10-35%	3.0%	7.00%	Low	Moderate
Salt 32	138	Moderate-Low	20-65%	3.0%	3.00%	Low	Minor
Salt 33A	109	Moderate	10-30%	2.5%	7.00%	Low	Moderate
Salt 33B	16	Low	10-15%	0.0%	7.00%	Low	Minor
Salt 33C	31	Moderate	20-40%	3.0%	7.00%	Low	Moderate
Salt 36	35	Low	10-20%	1.7%	7.00%	Low	Minor
Salt 37 (Dropped alt 3)	10	Moderate	20-50%	3.0%	7.00%	Low	Moderate
Salt 40 (Dropped alt 3)	17	Moderate	20-40%	3.0%	7.00%	Low	Moderate
Salt 45	103	Moderate-High	10-40%	3.0%	7.00%	Low	Moderate

Appendix D. Brad Rust Field Results

Table D-1. Results of Rust 2007 field work.

Unit #	Slope Range %	Soil Cover %	Duff Depth (in)	LWD (logs/ac)
1	30-40	100	2.5	No data
2	20-35	100	1.8	-
3	20-40	100	5.0	-
5	30-40	98	2.0	-
10	15-40	90	2.0	-
12	20-40	90	1.0	-
17	10-25	98	1.7	-
23	20-40	95	0.5	-
25	20-45	100	2.5	-
26	20-45	96	2.1	-
30	5-35	95	2.5	10-20
32	25-45	100	3.3	3-15
33	20-40	100	2.8	1-5
36	10-30	98	1.5	4-20
37	35-45	100	3.8	3-8
40	20-40	100	2.4	5-10
43	5-35	90	1.0	4-10

Taken from B. Rusts resource report and field work.

Appendix E. Summary of Jacqueline Foss' field work

Table E-1. Summary of Foss 2008 Field work

Unit #	Total # Plots	Unit Detrimental Disturbance (%)	Skid trail in unit (%)	detrimental skid trail in unit (%)	Skid trails that are detrimental (%)	Bare Soil	Rock	Vegetat ion	Litter	Wood	% cover	Down Woody Debris (T/Ac.)
Salt 1	80	2.50%	13.8%	2.5%	18.2%	5.0%	1.3%	8.8%	80.0%	5.0%	95.0%	8.8
Salt 2a	50	2.00%	12.0%	2.0%	16.7%	3.7%	1.4%	5.7%	79.8%	9.5%	96.3%	7.2
Salt 2b	60	5.00%	13.3%	5.0%	37.5%	1.7%	0.0%	8.3%	85.0%	5.0%	98.3%	2.6
Salt 2c	90	2.22%	7.8%	2.2%	28.6%	4.3%	2.9%	0.0%	74.3%	18.6%	95.7%	5.1
Salt 3	60	3.33%	11.7%	3.3%	28.6%	10.0%	5.0%	0.0%	78.3%	6.7%	90.0%	11.8
Salt 4	40	0.00%	2.5%	0.0%	0.0%	2.6%	10.3%	2.6%	71.8%	12.8%	97.4%	1.9
Salt 5	60	1.67%	11.7%	1.7%	14.3%	10.0%	8.3%	3.3%	70.0%	8.3%	90.0%	19.7
Salt 6	38	2.63%	13.2%	2.6%	20.0%	7.9%	18.4%	2.6%	60.5%	10.5%	92.1%	5.7
Salt 7	60	5.00%	18.3%	5.0%	27.3%	5.0%	3.3%	0.0%	80.0%	11.7%	95.0%	9.4
Salt 9A	61	3.28%	11.5%	3.3%	28.6%	1.6%	1.6%	0.0%	96.7%	0.0%	98.4%	2.6
Salt 9B	61	3.28%	11.5%	3.3%	28.6%	1.6%	1.6%	0.0%	96.7%	0.0%	98.4%	2.6
Salt 10	60	5.00%	15.0%	5.0%	33.3%	5.0%	1.7%	3.3%	81.7%	8.3%	95.0%	6.4
Salt 11	60	5.00%	18.3%	3.3%	18.2%	8.3%	11.7%	0.0%	71.7%	8.3%	91.7%	1.0
Salt 12	60	5.00%	28.3%	5.0%	17.6%	5.0%	5.0%	0.0%	78.3%	11.7%	95.0%	12.5
Salt 13	40	10.00%	17.5%	10.0%	57.1%	0.0%	0.0%	7.5%	85.0%	7.5%	100.0%	1.4
Salt 14	60	5.00%	20.0%	3.3%	16.7%	1.7%	0.0%	15.0%	78.3%	5.0%	98.3%	7.3
Salt 17	60	0.00%	10.0%	0.0%	0.0%	3.3%	1.7%	6.7%	83.3%	5.0%	96.7%	10.5
Salt 18	40	2.50%	5.0%	0.0%	0.0%	0.0%	22.5%	10.0%	60.0%	7.5%	100.0%	26.9
Salt 20*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
Salt 21	58	5.17%	15.5%	3.4%	22.2%	1.7%	1.7%	16.7%	73.3%	6.7%	98.3%	15.3
Salt 22	80	1.25%	8.8%	1.3%	14.3%	6.3%	10.0%	3.8%	77.5%	2.5%	93.8%	3.7
Salt 25A	60	1.67%	11.7%	1.7%	14.3%	3.3%	13.3%	5.0%	73.3%	5.0%	96.7%	17.2
Salt 25B	60	3.33%	10.0%	3.3%	33.3%	1.7%	10.0%	6.7%	61.7%	20.0%	98.3%	9.1
Salt 25C	68	0.00%	1.5%	0.0%	0.0%	7.8%	12.5%	1.6%	68.8%	9.4%	92.2%	21.8
Salt 25D	68	0.00%	1.5%	0.0%	0.0%	7.8%	12.5%	1.6%	68.8%	9.4%	92.2%	21.8

Unit #	Total # Plots	Unit Detrimental Disturbance (%)	Skid trail in unit (%)	detrimental skid trail in unit (%)	Skid trails that are detrimental (%)	Bare Soil	Rock	Vegetat ion	Litter	Wood	% cover	Down Woody Debris (T/Ac.)
Salt 25E	60	3.33%	11.7%	1.7%	14.3%	8.3%	3.3%	8.3%	73.3%	6.7%	91.7%	14.6
Salt 26	60	3.33%	10.0%	3.3%	33.3%	1.7%	10.0%	6.7%	61.7%	20.0%	98.3%	9.1
Salt 30A*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
Salt 30B*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
Salt 32*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
Salt 33A	80	2.50%	12.5%	2.5%	20.0%	5.0%	2.5%	1.3%	81.3%	10.0%	95.0%	14.5
Salt 33B	60	0.00%	6.7%	0.0%	0.0%	1.7%	0.0%	1.7%	88.3%	8.3%	98.3%	10.5
Salt 33C*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
Salt 36	60	1.67%	10.0%	1.7%	16.7%	0.0%	0.0%	0.0%	96.7%	3.3%	100.0%	14.0
Salt 37*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
Salt 40*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
Salt 45*	0	2.95%	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2
		average	11.8%	2.6%	22.4%	4.2%	5.9%	4.4%	77.1%	8.4%	95.8%	10.2

* Calculated from average of whole population

Appendix F. Current Science for Soil Quality Monitoring

Direction exists at virtually all levels to consider past monitoring, new information, and current science in the evaluation of resource management practices and the decision making framework.

Long-Term Soil Productivity Study

The Long-Term Soil Productivity (LTSP) Study was borne in direct response to NFMA and the National Soil Management Handbook to help validate and refine indicators and thresholds used in the SQAS. This effort was cooperatively undertaken by Forest Service Research and Forest Service Systems, and is an ongoing nation-wide experimental study.

An extensive world-wide literature review was first conducted looking for real evidence of productivity declines and causes, beyond anecdotal and confounded studies. Where productivity declines were well documented, the causal factors commonly reported were compaction and/or organic matter removal from the site.

An experimental design was developed by Robert Powers and others to investigate these factors, peer-reviewed world-wide, and site installations began in 1990 in the southern coastal plain ecoregion. In brief, the study design involves 3 levels of compaction (none, intermediate, and severe) and 3 levels of organic matter removal (bole only, whole tree, and whole tree + all forest floor), in factorial combinations for 9 treatments. Sites were clearcut, treatments applied, and then planted with native conifer species. In addition, plots were split in half, where competing vegetation was controlled in one half but not the other. Some sites had additional “mitigation plots” where they were impacted and then rehabilitated by means such as subsoiling, to test effectiveness of rehab methods.

It is important to note with LTSP that “severe compaction” was experimental- approx. 90-95 percent of the area was heavily compacted (everywhere but stumps). Both in terms of extent and severity this greatly exceeds impacts of typical harvest operations; severity may be typical of landings. Intermediate compaction would be more typical in severity to well-used skid trails, though again much more extensive than typical operations (90-95 percent area). In terms of organic matter removal, fuel reduction projects such as the proposed action would be typified by whole tree + some forest floor removal.

California has 12 such installations, more than any other Region, established from 1991 to 1998. CA installations were purposely placed on a variety of major forest soils, to investigate relationships on different soil types. Total aboveground productivity has been measured at 5-year intervals. Results to date as they pertain to soils typical of the project area will be discussed in the environmental effects section.