SOIL SPECIALIST REPORT

Giant Sequoia National Monument Management Plan

Fresno, Tulare and Kern Counties
Sequoia National Forest
Giant Sequoia National Monument

PREPARED BY: ____________________ DATE July 19th, 2012

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Introduction

The Clinton Proclamation establishing Giant Sequoia National Monument (Monument) required establishment of a Monument management plan. There are a number of existing management directions that are applicable to the Giant Sequoia National Monument concerning soil conservation and productivity.

Current Management Direction

The 1990 Sequoia National Forest Land Management Plan Mediated Settlement Agreement (MSA) recommended that the Forest use the Pacific Southwest Region Draft Soil Quality Standards and Guidelines. In 1995, the Pacific Southwest Region finalized the Soil Quality Standards and Guidelines.

The 2001 Sierra Nevada Forest Plan Amendment (2001 SNFPA) FEIS and Record of Decision, amended the 1988 Sequoia National Forest Land and Resource Management Plan (Forest PLan) with updated scientific research regarding soils, and updated standards and guidelines to maintain or improve soil quality. This current analysis for the Monument will rely on the most current scientific information available.

Regional Best Management Practices

Best Management Practices (BMPs) protect water quality, primarily by reducing unnatural erosion. These practices are enforced by the State Water Quality Board to implement State and Federal Clean Water Laws. The BMPs are designed to also implement standards to protect soil quality.

Description of Proposal

Below is a description of elements of the six alternatives in the draft EIS considered important to soil conservation and productivity. A complete description of the Alternatives can be found in Chapter 2 of the draft EIS.

No Action Alternative

This alternatives contain the standards and guidelines for soil productivity and conservation adopted in the 2001 SNFPA, Appendix F (pp. 1-5).

Soil Productivity

A. Soil loss should not exceed the average rate of soil formation. Maintain sufficient soil cover to prevent accelerated soil erosion from exceeding the rate of soil formation. Use the California Soil Survey Committee Soil Erosion Hazard Rating system (R-5 FSH 2509.22, Ch. 50) to determine the kind, amount and distribution of soil cover necessary to avoid detrimental accelerated soil erosion. Locally adapted standard erosion models and measurements can be used to refine soil loss tolerances and effective ground cover requirements. Relevant ranges in ground cover for many ecological types can be found in Regional Ecological Guides (R4-ECOL-99-01, R5-ECOLTP-003 & PSW-GTR-169, R5-ECOL-TP-004).

Prescribe the kinds and amounts of soil cover that would not elevate wildfire risk or severity to the point that fuel management and soil quality objectives cannot be met. If there is no viable alternative for providing soil cover without elevating the risk of adverse wildfire effects, prescribe minimum soil cover needed to avoid detrimental soil loss.

B. Soil porosity should be at least 90 percent of total porosity found under natural conditions. A 10 percent reduction in total soil porosity corresponds to a threshold soil bulk density that indicates detrimental soil compaction. Measure initial soil porosities within an activity area where there is a potential for soil compaction to occur. For post-activity assessment, measure adjacent uncompacted areas. Compare threshold porosity with post-activity porosity in the rooting zone between 6 and 10 inches below the soil surface to evaluate the potential for detrimental soil compaction. Additional depth or zones may be evaluated if necessary to better describe conditions/rooting zones at a site.

C. Organic matter is maintained in amounts sufficient to prevent significant short or long-term nutrient cycle deficits, and to avoid detrimental physical and biological soil conditions.

Prescribe surface organic matter in amounts that would not elevate wildfire risk or severity to the point that desired organic matter for nutrient cycling cannot be achieved or maintained because of increased wildfire risk potential. If there is no viable alternative for providing surface organic matter without elevating wildfire risk, prescribe an amount that does not significantly increase wildfire risk and monitor soil nutrient status. Apply mitigation measures if decreased nutrient supply has the potential to affect ecosystem health, diversity or productivity. The prescribed amount shall not reduce the amount needed for soil cover to prevent accelerated erosion (section 2.2, paragraph 1a of the 2001 SNFPA).

Use the kinds and amounts of organic matter identified below. These may be supplemented with local analyses and adjusted to levels appropriate for specific ecological types.

(1) Soil organic matter in the upper 12 inches of soil is at least 85 percent of the total soil organic matter found under natural conditions for the same or similar soils. Soil organic matter is used as an indicator of soil displacement effects on nutrient and soil moisture supply. Detrimental displacement is the loss of either 5 cm (2 inches) or one-half of the humus enriched top soil (A-horizon), whichever is less, from a 1 meter square area or larger.

(2) Surface organic matter is present in the following forms and amounts.

(a) Fine organic matter occurs over at least 50 percent of the area and is well distributed. Fine organic matter includes plant litter, duff, and woody material less than 3 inches in diameter. The dry weight of fine organic matter without woody material is about 0.2 to 3 tons per acre.

The preference is for fine organic matter to be undisturbed, but if disturbed, the quantity and quality should avoid detrimental short and long-term nutrient cycle deficits. Determine minimum organic layer thickness and distribution locally and base it on amounts sufficient to persist through winter season storms and summer season oxidation.

Use the presence of living vegetation that could contribute significant annual litter fall to compensate for conditions when immediate post-disturbance fine organic matter coverage is too thin or less than 50 percent.

If the soil and potential natural plant community are not capable of producing fine organic matter over 50 percent of the area, adjust minimum amounts to reflect potential soil and vegetation capability.

(b) Large downed woody material is a critical component of old forest wildlife habitat and in addition provides for moisture retention, and microhabitat for soil flora and fauna. The minimum amount of large woody debris required to maintain habitat and moisture supplies adequate to sustain site productivity varies by ecological type. Forests should develop reference variability for large down woody material for ecological units. Adjust the minimum logs per acre to account for ecological type potential (FSH 2090.11) and specific site needs as data becomes available, recognizing that data is currently lacking for certain eastside pine and hardwood types.

In general and in areas without more specific large downed woody material requirements determined by ecological type, use the following guidelines:

There should be at least 5 well-distributed logs per acre representing the range of decomposition classes (Maser et al. 1979). Desired logs are at least 20 inches in diameter and 10 feet long. Do not count logs less than 12 inches in diameter or stumps as large woody material. Protect logs in decomposition classes 3 through 5 from mechanical disturbance. To alleviate the risk of adverse fire effects and wildfire, dry weight of large woody material should be less than about 3 tons per acre and dry weight of fine organic matter and large woody material together should amount to less than about 6 tons per acre except where standards and guidelines for wildlife call for more.

To help meet fuel management objectives, minimum logs can be adjusted to take advantage of short-term large woody material contributions in snag recruitment areas. In areas with sufficient snags and deficient large down woody material, excess snags may be felled after prescribed burning treatment to help replenish logs lost in burning. Large woody material and fine organic matter amounts (except when needed for essential erosion control) may be reduced to meet fuel management objectives in strategic fuel treatment areas, on fuel breaks, and in other critical areas. Evaluate or monitor soil nutrient status in fuel treatment areas and other areas that lack sufficient large woody material and fine organic matter.

Soil Hydrologic Function

Soil Moisture Regime is unchanged where productivity or potential natural plant community are dependent upon specific soil drainage classes. Use natural soil drainage classes (USDA Handbook No. 18, Soil Survey Division Staff, 1993) to evaluate the effect of management induced watertable or subsurface flow changes on plant growth or potential plant community composition.

Soil Buffering Capacity

Do not add materials to the soil in amounts sufficient to alter soil reaction class, buffering or exchange capacities, or microorganism populations to the degree that significantly impairs soil productivity, bioremediation potential, soil hydrologic function, or the health of humans or animals.

All Action Alternatives except Alternative E

All Action alternatives (except E) contain updated standards and guidelines for soil conservation and productivity. This update was based of incorporating new science and resulting new management recommendations into the existing standards/guidelines from the 2001 Framework.

Soil standards and guidelines apply to those areas dedicated to growing vegetation. They do not apply to national forest system roads, authorized trails, campgrounds, administrative sites or other particular areas with other dedicated uses of the land.

Standard 1. During NEPA complete the assessments and risk evaluations listed below for project areas with proposed activities which have the greatest potential to cause erosion, displacement, reduce soil porosity, or affect areas with aquic soil moisture regimes.

- Assess current soil condition in project areas with proposed activities that have the greatest potential to cause adverse soil property change.

- Evaluate soil erosion risk during project planning and recommend soil cover retention levels needed to minimize erosion.

- Evaluate the risk of soil displacement from the proposed activities and where needed, provide recommendations to prevent adverse effects. During risk analysis consider topsoil thickness, total soil depth, slope, topography, kind of activity/equipment involved, and percentage of area that could be affected.

- Determine if soils with aquic soil moisture conditions occur in the project area. If present assess current soil condition and if needed, recommend measures to sustain or restore the aquic soil moisture regime. Evaluate the risk of soil porosity loss (compaction) for the major soil types in the project area and if needed, recommend mitigations to reduce adverse effects.

- For projects involving the application of chemicals, such as herbicides, pesticides, or other amendments, evaluate the effects to soil micro-organisms, post-project erosion risk, leaching potential, and risk of off-site movement of the chemicals. Provide recommendations to prevent adverse effects.

Standard 2. During management activities maintain an average of 50% effective soil cover where treatments are implemented that is well distributed and generally in the form of fine organic matter.

- Fine organic matter includes plant litter, duff, and woody material less than 3 inches in diameter. “Effective” soil cover means the thickness and continuity of soil cover provides adequate protection to prevent rill network formation.

- Management activities in areas with ecological types that cannot normally support 50% soil cover will need to be considered individually for soil cover needs. In special areas such as fuel breaks and defense zones immediate post treatment soil cover levels less than 50% will be allowed as long as the site conditions and actual cover level will prevent erosion. Field review and monitoring (adaptive management) should be used to determine what minimal level of soil cover is necessary in the special areas.

Standard 3. Retain 100% of soil cover in a 100 foot wide buffer below rock outcrops that have the potential to generate runoff into management activity areas and cause erosion.

Standard 4. For areas where sustained slopes exceed 35%, limit mechanical operations such as log skidding, tractor piling, grapple piling and mastication, except where supported by on-the-ground interdisciplinary team evaluation that includes a watershed specialist.

Standard 5. Limit total soil displacement and total soil porosity reduction (compaction) to less than 15% of the activity area. No more than 10 % of the activity area can be displaced.

- Temporary roads, temporary landings, and skid trails will be considered lands dedicated to growing vegetation and part of the activity area to evaluate. Excluded areas from this standard include national forest system roads, trails, and facility or other dedicated sites.

- An observation point will be considered displaced if more than one-half of the thickness of the topsoil or A horizon has been removed from a contiguous area larger than 100 sq. ft. An observation point will be considered compacted if there is less than 90% total soil porosity in a contiguous area greater than 100 sq. ft compared to undisturbed soils nearby. Conduct operations when soil porosity, especially macroporosity, will be maintained at a level sufficient for soil hydrologic function and long term soil productivity for plant growth. Utilize the latest findings of the Long Term Soil Productivity study of Powers and other studies to evaluate the effects to soil productivity from porosity changes.

Standard 6. Maintain aquic soil moisture conditions (defined in Soil Taxonomy, 1999), in wet meadows and fens.

- Areas with aquic soil moisture regime include wet meadows and fens where soil moisture levels remain high throughout most of the year.

- Maintain soil structure and porosity.

- Use the presence and density of water dependent vegetation as an indicator to evaluate soil moisture condition.

Standard 7. Maintain downed logs for soil organisms based upon the ecological type and in consultation with wildlife and fuels.

Alternative E

Alternative E (the MSA Alternative) incorporates standards and guidelines for soils from the 1995 Forest Service Soil Management Handbook, R5 Supplement No. 2509.18-95-1. These standards and guidelines are very similar to the current ones adopted in the SNFPA 2001 for the No Action Alternative.

Soil Productivity

A. Soil loss should not exceed the rate of soil formation (approximately the long-term average of

1 ton/acre/year). Maintain sufficient soil cover to prevent accelerated soil erosion from exceeding the rate of soil formation.

Use Region 5 Soil Erosion Hazard Rating system (R-5 FSH 2509.22, Ch. 50) to determine the kind, amount and distribution of soil cover necessary to avoid detrimental accelerated soil erosion. Locally adapted standard erosion models and measurements can be used to refine soil cover requirements.

Effective soil cover for reducing the risk of accelerated soil erosion includes living vegetation (grasses, forbs and prostrate shrubs), plant and tree litter (fine organic matter), surface rock fragments, and applied mulches (straw or chips). Depending upon the kinds of soil cover present and other erosion hazard factors, the amount of fine organic matter necessary to reduce the risk of detrimental soil loss may be more or less than the amount needed for nutrient cycling (item c).

Prescribe the kinds and amounts of soil cover that would not elevate wildfire risk or severity to the point that fuel management and soil quality objectives cannot be met. If there is no viable alternative for providing soil cover without elevating the risk of adverse wildfire effects, prescribe minimum soil cover needed to avoid detrimental soil loss.

B. Soil porosity should be at least 90 percent of total porosity found under natural conditions. A 10 percent reduction in total soil porosity corresponds to a threshold soil bulk density that indicates detrimental soil compaction.

Use the table or formula in Exhibit 01 to find the threshold soil bulk density that corresponds to the appropriate initial soil bulk density. Measure initial soil densities within an activity area where there is a potential for soil compaction to occur. For post-activity assessment, measure adjacent uncompacted areas. Compare threshold density with post-activity density between 4 and 8 inches below the soil surface to evaluate the potential for detrimental soil compaction.

C. Organic matter is maintained in amounts sufficient to prevent significant short or long-term nutrient cycle deficits, and to avoid detrimental physical and biological soil conditions.

Prescribe surface organic matter in amounts that would not elevate wildfire risk or severity to the point that desired organic matter for nutrient cycling cannot be achieved or maintained because of increased wildfire risk potential. If there is no viable alternative for providing surface organic matter without elevating wildfire risk, prescribe an amount that does not significantly increase wildfire risk and monitor soil nutrient status. Apply mitigation measures if decreased nutrient supply has the potential to affect ecosystem health, diversity or productivity. The prescribed amount shall not reduce the amount needed for soil cover to prevent accelerated erosion (section 2.2, paragraph 1a).

Use the kinds and amounts of organic matter identified below. These may be supplemented with local analysis.

(1) Soil organic matter in the upper 12 inches of soil is at least 85 percent of the total soil organic matter found under natural conditions for the same or similar soils. Soil organic matter is used as an indicator of soil displacement effects on nutrient and soil moisture supply.

(2) Surface organic matter is present in the following forms and amounts.

(a) Fine organic matter occurs over at least 50 percent of the area. Fine organic matter includes plant litter, duff, and woody material less than 3 inches in diameter. The dry weight of fine organic matter without woody material is about 0.2 to 3 tons per acre.

The preference is for fine organic matter to be undisturbed, but if disturbed, the quantity and quality should avoid detrimental short and long-term nutrient cycle deficits. Determine minimum organic layer thickness and distribution locally and base it on amounts sufficient to persist through winter season storms and summer season oxidation.

Use the presence of living vegetation that could contribute significant annual litter fall to compensate for conditions when immediate post-disturbance fine organic matter coverage is too thin or less than 50 percent.

If the soil and potential natural plant community are not capable of producing fine organic matter over 50 percent of the area, adjust minimum amounts to reflect potential soil and vegetation capability.

(b) Large woody material is at least 5 well distributed logs per acre representing the range of decomposition classes defined in Exhibit 02. To alleviate the risk of adverse fire effects, dry weight should be less than about 3 tons per acre.

Desired logs are at least 20 inches in diameter and 10 feet long. Protect logs in decomposition classes 3 through 5 from mechanical disturbance. Do not count logs less than 12 inches in diameter or stumps as large woody material.

Adjust the minimum logs per acre to account for ecological type (FSH 2090.11) potential and specific site needs as data becomes available. To help meet fuel management objectives, minimum logs can be adjusted to take advantage of short-term large woody material contributions in snag recruitment areas.

(c) Fine organic matter and large woody material together should amount to less than about 6 tons per acre dry weight to alleviate the risk of potential detrimental wildfire effects. Other surface organic matter (3 inches to 20 inches in diameter), or amounts of fine organic matter and large woody material in excess of amounts described in detail above need not be retained.

Large woody material and fine organic matter amounts (except when needed for essential erosion control) may be reduced to meet fuel management objectives in strategic fuel treatment areas, on fuel breaks, and in other critical areas. Evaluate or monitor soil nutrient status in fuel treatment areas and other areas that lack sufficient large woody material and fine organic matter.

(d) Soil Moisture Regime is unchanged where productivity or potential natural plant communities are dependent upon specific soil drainage classes. Use natural soil drainage classes to evaluate the effect of management induced watertable or subsurface flow changes on plant growth or potential plant community composition.

Soil Hydrologic Function

To avoid accelerated surface runoff, infiltration and permeability are not reduced to ratings of 6 or 8 as defined in Region 5 Erosion Hazard Rating system (R-5 FSH 2509.22, Ch. 50).

Soil Buffering Capacity

Materials added to the soil must not alter soil reaction class, buffering or exchange capacities, or microorganism populations to the degree that significantly affects soil productivity, bioremediation potential, soil hydrologic function, or the health of humans or animals.

Develop local threshold values as the need arises and submit to the Regional Forester for standardization among forests.

Affected Environment

The Monument has a great variety of soil types. Primarily, these soils differ in their parent material, climate, topography, vegetation, and degree of development.

The soils in the Monument are primarily derived from solid bedrock, mostly igneous granite with smaller areas of metamorphic roof pendants. Topography varies widely across the Monument. The lower elevations have steep slopes and are more highly dissected into drainages and ridgelines. The higher elevations tend to have more subdued topography with gentle basins and moderate slopes. Vegetation types range from blue oak savanna at lower elevations up through chaparral and hardwood forest to expansive conifer forests at the higher elevations (5,000 to 12,000 feet). Warmer temperatures, sufficient precipitation, and gentle topography create great conditions for soil development at the middle elevations (5,000 to 7,500 feet) within the Monument. Soils are less well developed at higher (>7,500 feet) because of lower temperatures and a consequent shorter growing season. At lower elevations (< 5,000 feet) a lack of precipitation and a pronounced summer drought are what limit soil development.

These differences result in a broad range of soil productivity across the Monument. In general, the most productive soils are found at middle elevations on the westside of the Great Western Divide and the main crest of the Sierra Nevada. These soils are concentrated in an elevation belt (5,000 to 7,000 feet), where favorable temperature and precipitation supports ponderosa pine, west side mixed conifer, and giant sequoia vegetation types. Soils tend to be shallower, less well developed, and coarser textured at higher elevations (7,000 to 12,000 feet) within the Monument. Soil information detailed within this section comes from the Sequoia National Forest Soil Survey (1996) unless otherwise attributed.

Soil Characteristics and Classification

Soils are generally drier in the western portions of the Monument or where they are shallow due to steep slopes. High runoff is common in these portions of the monument, and occurs because the infiltration rate of the soils is often exceeded by rainfall intensity. This has the potential to affect rainfall runoff amounts and timing. Soils found in these lower foothills are typically moderately deep, gently rolling to very steep, and well drained. The soils range from rock outcrops to coarse sandy loam to clay. The soils in the drainages consist of medium and fine-textured soils developed in alluvium weathered from igneous and metamorphic rocks. The soil chemistry varies in acidity from neutral to medium acid, with infiltration rates that vary from slow to moderate.

At the middle elevations, especially in flatter terrain along the meadow areas and basins soil infiltration and depth is moderate to good due to generally moderate to deep soils on granite bedrock. Where soils are deeper the water holding capacity of the soil is generally good. Soils are shallowest in the ridges from 7,000 feet and above and deepen as one descends into the foothills on the west site of the Monument. Soil infiltration and depth is poor to moderate at the higher elevations around areas of exposed bedrock monoliths and outcrops.

Soils in the northern portion of the Monument, generally in the Kings River watershed, are predominantly comprised of coarse sandy loam and sandy clay loam derived from granitic rock of the Chawanakee-Chaix and Dome-Chaix series. In the areas of caves and marble roof pendants, the soil is derived from metamorphic rock in the Hotaw-Brownlee-Rock Outcrop series. The higher acidity soils are found in the region of caves in the northern portion of the Monument. This is from the formation of carbonic acid as ground water flows through marble roof pendants. Rainwater and snowmelt disappear into fissures and later flow into underground rivers, eventually flowing into the Kings River downstream of the marble bearing formations.

Soils in the southern portion of the Monument, generally in the Tule River and Kern River Watersheds, are predominantly comprised of coarse sandy loam and sandy clay loam of the Glean Variant, Bald Mountain, Chaix, Chawanakee, Holland, Woolstaff, Wind River, and Hotaw series. These soils were formed in place from parent granitic bedrock and limited areas of metamorphic rock. Minor deposits of alluvium and colluvium occur at scattered locations throughout Monument.

Soil Erosion Hazard Ratings

The specific soil associations with high and very high erosion potential within the monument are shown in the following table. The soil associations are shown with their percent in the monument area, erosion hazard rating (EHR), predominant soil texture, and slope range. A high or very high rating means accelerated erosion can occur, and the need for erosion control measures should be evaluated during project level analysis.

Table 1 Soil Associations with Very High Erosion Hazard within the Project Area

Soil Association	Chawanakee-Chaix-Outcrop Complex	Outcrop-Cieneba-Chawanakee Complex	Toem-Outcrop-Cagwin Complex	Rock Outcrop
Soil Texture	Sandy Loam	Sandy Loam	Sandy Loam	Sandy
Slope Percent	30-75	30-75	30-50	30-75

Soil Associations with Very High EHRs account for approximately 5 percent of the Monument.

Table 2 Soil Associations with High Erosion Hazard within the Project Area.

Soil Association	Hotaw-Brownlee-Outcrop Complex	Chiax-Dome-Outcrop Complex	Shaver Chaix Association	Holland-Bohna Association
Erosion hazard rating	High	High	High	High
Soil Texture	Sandy loam	Sandy loam	Sandy loam	Sandy Loam
Slope Percent	30-75	30-75	30-50	30-50

Soil Associations with High EHRs account for approximately 40 percent of the Monument.

Soils and Invasive Nonnative Species

Invasive nonnative species are often early invaders after soil disturbance. While some of these species may stabilize nutrients and soil cover, most tend to out compete and replace native vegetation. Different soil organisms predominate under different kinds of vegetation. Replacement of native plant communities with invasive nonnative species can be expected to change soil microbial populations and thus nutrient cycling processes. Many of these annuals have shallow root systems that make them poor candidates for stabilizing soil surfaces and providing erosion protection. Some invasive exotic plants, such as salt cedar (*Tamarisk chinensis, Tamarisk spp*.) affect soil moisture and salt balance (Neill 1983).

Invasive nonnative species are controlled using chemical, biological, mechanical, and cultural methods. Chemical and biological treatment methods generally result in lower impacts to soil properties because these treatments do not physically disturb the soil. This presumes that these methods have negligible effects on soil microorganisms.

Soil Conservation Practices

The correlation between management impacts on soil properties and changes in long-term soil productivity has not been completely determined. However, current soil science points to three basic soil conservation practices for maintaining long-term soil productivity.

- During land management activities, maintain adequate cover to protect the soil from erosion. Soil cover can include litter, duff, limbs, and other vegetative material, rock fragments, living vegetation, or applied mulches, such as straw or wood chips.

- During land management activities, limit the amount of area where detrimental compaction or movement of soil occurs. This can be accomplished by:

    1. Identifying soil characteristics in the area being managed;
    2. Selecting a management method, including the type of equipment, appropriate to soil capabilities and limitations;
    3. Timing activities appropriately; and
    4. Limiting the area where the activity is allowed to occur. This practice may include repairing areas of detrimental compaction by deferring management activities or

subsoiling (loosening soil layers from below with minimal mixing of surface layers).

- Maintain levels of organic matter on the soil surface and within the soil that are sufficient for the nutrient cycling and maintaining soil microorganisms. Woody material, litter, and duff are sources of soil nutrients. Woody material provides habitat for small animals, microorganisms, and insects. Many of these organisms convert nutrients in woody material, litter, and duff to forms usable by vegetation. Soil arthropods, microbes, and fungi work in concert to regulate the decomposition rates and nutrient cycling (Moldenke 1993).

Environmental Effects

Legal and Regulatory Compliance

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B. Soil porosity should be at least 90 percent of total porosity found under natural conditions. A 10 percent reduction in total soil porosity corresponds to a threshold soil bulk density that indicates detrimental soil compaction. Measure initial soil porosities within an activity area where there is a potential for soil compaction to occur. For post-activity assessment, measure adjacent uncompacted areas. Compare threshold porosity with post-activity porosity in the rooting zone between 6 and 10 inches below the soil surface to evaluate the potential for detrimental soil compaction. Additional depth or zones may be evaluated if necessary to better describe conditions/rooting zones at a site.

C. Organic matter is maintained in amounts sufficient to prevent significant short or long-term nutrient cycle deficits, and to avoid detrimental physical and biological soil conditions.

Prescribe surface organic matter in amounts that would not elevate wildfire risk or severity to the point that desired organic matter for nutrient cycling cannot be achieved or maintained because of increased wildfire risk potential. If there is no viable alternative for providing surface organic matter without elevating wildfire risk, prescribe an amount that does not significantly increase wildfire risk and monitor soil nutrient status. Apply mitigation measures if decreased nutrient supply has the potential to affect ecosystem health, diversity or productivity. The prescribed amount shall not reduce the amount needed for soil cover to prevent accelerated erosion (section 2.2, paragraph 1a of the 2001 SNFPA).

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Use the presence of living vegetation that could contribute significant annual litter fall to compensate for conditions when immediate post-disturbance fine organic matter coverage is too thin or less than 50 percent.

If the soil and potential natural plant community are not capable of producing fine organic matter over 50 percent of the area, adjust minimum amounts to reflect potential soil and vegetation capability.

(b) Large downed woody material is a critical component of old forest wildlife habitat and in addition provides for moisture retention, and microhabitat for soil flora and fauna. The minimum amount of large woody debris required to maintain habitat and moisture supplies adequate to sustain site productivity varies by ecological type. Forests should develop reference variability for large down woody material for ecological units. Adjust the minimum logs per acre to account for ecological type potential (FSH 2090.11) and specific site needs as data becomes available, recognizing that data is currently lacking for certain eastside pine and hardwood types.

In general and in areas without more specific large downed woody material requirements determined by ecological type, use the following guidelines:

There should be at least 5 well-distributed logs per acre representing the range of decomposition classes (Maser et al. 1979). Desired logs are at least 20 inches in diameter and 10 feet long. Do not count logs less than 12 inches in diameter or stumps as large woody material. Protect logs in decomposition classes 3 through 5 from mechanical disturbance. To alleviate the risk of adverse fire effects and wildfire, dry weight of large woody material should be less than about 3 tons per acre and dry weight of fine organic matter and large woody material together should amount to less than about 6 tons per acre except where standards and guidelines for wildlife call for more.

To help meet fuel management objectives, minimum logs can be adjusted to take advantage of short-term large woody material contributions in snag recruitment areas. In areas with sufficient snags and deficient large down woody material, excess snags may be felled after prescribed burning treatment to help replenish logs lost in burning. Large woody material and fine organic matter amounts (except when needed for essential erosion control) may be reduced to meet fuel management objectives in strategic fuel treatment areas, on fuel breaks, and in other critical areas. Evaluate or monitor soil nutrient status in fuel treatment areas and other areas that lack sufficient large woody material and fine organic matter.

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Soil standards and guidelines apply to those areas dedicated to growing vegetation. They do not apply to national forest system roads, authorized trails, campgrounds, administrative sites or other particular areas with other dedicated uses of the land.

Standard 1. During NEPA complete the assessments and risk evaluations listed below for project areas with proposed activities which have the greatest potential to cause erosion, displacement, reduce soil porosity, or affect areas with aquic soil moisture regimes.

- Assess current soil condition in project areas with proposed activities that have the greatest potential to cause adverse soil property change.

- Evaluate soil erosion risk during project planning and recommend soil cover retention levels needed to minimize erosion.

- Evaluate the risk of soil displacement from the proposed activities and where needed, provide recommendations to prevent adverse effects. During risk analysis consider topsoil thickness, total soil depth, slope, topography, kind of activity/equipment involved, and percentage of area that could be affected.

- Determine if soils with aquic soil moisture conditions occur in the project area. If present assess current soil condition and if needed, recommend measures to sustain or restore the aquic soil moisture regime. Evaluate the risk of soil porosity loss (compaction) for the major soil types in the project area and if needed, recommend mitigations to reduce adverse effects.

- For projects involving the application of chemicals, such as herbicides, pesticides, or other amendments, evaluate the effects to soil micro-organisms, post-project erosion risk, leaching potential, and risk of off-site movement of the chemicals. Provide recommendations to prevent adverse effects.

Standard 2. During management activities maintain an average of 50% effective soil cover where treatments are implemented that is well distributed and generally in the form of fine organic matter.

- Fine organic matter includes plant litter, duff, and woody material less than 3 inches in diameter. “Effective” soil cover means the thickness and continuity of soil cover provides adequate protection to prevent rill network formation.

- Management activities in areas with ecological types that cannot normally support 50% soil cover will need to be considered individually for soil cover needs. In special areas such as fuel breaks and defense zones immediate post treatment soil cover levels less than 50% will be allowed as long as the site conditions and actual cover level will prevent erosion. Field review and monitoring (adaptive management) should be used to determine what minimal level of soil cover is necessary in the special areas.

Standard 3. Retain 100% of soil cover in a 100 foot wide buffer below rock outcrops that have the potential to generate runoff into management activity areas and cause erosion.

Standard 4. For areas where sustained slopes exceed 35%, limit mechanical operations such as log skidding, tractor piling, grapple piling and mastication, except where supported by on-the-ground interdisciplinary team evaluation that includes a watershed specialist.

Standard 5. Limit total soil displacement and total soil porosity reduction (compaction) to less than 15% of the activity area. No more than 10 % of the activity area can be displaced.

- Temporary roads, temporary landings, and skid trails will be considered lands dedicated to growing vegetation and part of the activity area to evaluate. Excluded areas from this standard include national forest system roads, trails, and facility or other dedicated sites.

- An observation point will be considered displaced if more than one-half of the thickness of the topsoil or A horizon has been removed from a contiguous area larger than 100 sq. ft. An observation point will be considered compacted if there is less than 90% total soil porosity in a contiguous area greater than 100 sq. ft compared to undisturbed soils nearby. Conduct operations when soil porosity, especially macroporosity, will be maintained at a level sufficient for soil hydrologic function and long term soil productivity for plant growth. Utilize the latest findings of the Long Term Soil Productivity study of Powers and other studies to evaluate the effects to soil productivity from porosity changes.

Standard 6. Maintain aquic soil moisture conditions (defined in Soil Taxonomy, 1999), in wet meadows and fens.

- Areas with aquic soil moisture regime include wet meadows and fens where soil moisture levels remain high throughout most of the year.
- Maintain soil structure and porosity.
- Use the presence and density of water dependent vegetation as an indicator to evaluate soil moisture condition.

Standard 7. Maintain downed logs for soil organisms based upon the ecological type and in consultation with wildlife and fuels.

Alternative E

Alternative E (the MSA Alternative) incorporates standards and guidelines for soils from the 1995 Forest Service Soil Management Handbook, R5 Supplement No. 2509.18-95-1. These standards and guidelines are very similar to the current ones adopted in the SNFPA 2001 for the No Action Alternative.

Soil Productivity

A. Soil loss should not exceed the rate of soil formation (approximately the long-term average of 1 ton/acre/year). Maintain sufficient soil cover to prevent accelerated soil erosion from exceeding the rate of soil formation.

Use Region 5 Soil Erosion Hazard Rating system (R-5 FSH 2509.22, Ch. 50) to determine the kind, amount and distribution of soil cover necessary to avoid detrimental accelerated soil erosion. Locally adapted standard erosion models and measurements can be used to refine soil cover requirements.

Effective soil cover for reducing the risk of accelerated soil erosion includes living vegetation (grasses, forbs and prostrate shrubs), plant and tree litter (fine organic matter), surface rock fragments, and applied mulches (straw or chips). Depending upon the kinds of soil cover present and other erosion hazard factors, the amount of fine organic matter necessary to reduce the risk of detrimental soil loss may be more or less than the amount needed for nutrient cycling (item c).

Prescribe the kinds and amounts of soil cover that would not elevate wildfire risk or severity to the point that fuel management and soil quality objectives cannot be met. If there is no viable alternative for providing soil cover without elevating the risk of adverse wildfire effects, prescribe minimum soil cover needed to avoid detrimental soil loss.

B. Soil porosity should be at least 90 percent of total porosity found under natural conditions. A

10 percent reduction in total soil porosity corresponds to a threshold soil bulk density that indicates detrimental soil compaction.

Use the table or formula in Exhibit 01 to find the threshold soil bulk density that corresponds to the appropriate initial soil bulk density. Measure initial soil densities within an activity area where there is a potential for soil compaction to occur. For post-activity assessment, measure adjacent uncompacted areas. Compare threshold density with post-activity density between 4 and 8 inches below the soil surface to evaluate the potential for detrimental soil compaction.

C. Organic matter is maintained in amounts sufficient to prevent significant short or long-term nutrient cycle deficits, and to avoid detrimental physical and biological soil conditions.

Prescribe surface organic matter in amounts that would not elevate wildfire risk or severity to the point that desired organic matter for nutrient cycling cannot be achieved or maintained because of increased wildfire risk potential. If there is no viable alternative for providing surface organic matter without elevating wildfire risk, prescribe an amount that does not significantly increase wildfire risk and monitor soil nutrient status. Apply mitigation measures if decreased nutrient supply has the potential to affect ecosystem health, diversity or productivity. The prescribed amount shall not reduce the amount needed for soil cover to prevent accelerated erosion (section 2.2, paragraph 1a).

Use the kinds and amounts of organic matter identified below. These may be supplemented with local analysis.

(1) Soil organic matter in the upper 12 inches of soil is at least 85 percent of the total soil organic matter found under natural conditions for the same or similar soils. Soil organic matter is used as an indicator of soil displacement effects on nutrient and soil moisture supply.

(2) Surface organic matter is present in the following forms and amounts.

(a) Fine organic matter occurs over at least 50 percent of the area. Fine organic matter includes plant litter, duff, and woody material less than 3 inches in diameter. The dry weight of fine organic matter without woody material is about 0.2 to 3 tons per acre.

The preference is for fine organic matter to be undisturbed, but if disturbed, the quantity and quality should avoid detrimental short and long-term nutrient cycle deficits. Determine minimum organic layer thickness and distribution locally and base it on amounts sufficient to persist through winter season storms and summer season oxidation.

Use the presence of living vegetation that could contribute significant annual litter fall to compensate for conditions when immediate post-disturbance fine organic matter coverage is too thin or less than 50 percent.

If the soil and potential natural plant community are not capable of producing fine organic matter over 50 percent of the area, adjust minimum amounts to reflect potential soil and vegetation capability.

(b) Large woody material is at least 5 well distributed logs per acre representing the range of decomposition classes defined in Exhibit 02. To alleviate the risk of adverse fire effects, dry weight should be less than about 3 tons per acre.

Desired logs are at least 20 inches in diameter and 10 feet long. Protect logs in decomposition classes 3 through 5 from mechanical disturbance. Do not count logs less than 12 inches in diameter or stumps as large woody material.

Adjust the minimum logs per acre to account for ecological type (FSH 2090.11) potential and specific site needs as data becomes available. To help meet fuel management objectives, minimum logs can be adjusted to take advantage of short-term large woody material contributions in snag recruitment areas.

(c) Fine organic matter and large woody material together should amount to less than about 6 tons per acre dry weight to alleviate the risk of potential detrimental wildfire effects. Other surface organic matter (3 inches to 20 inches in diameter), or amounts of fine organic matter and large woody material in excess of amounts described in detail above need not be retained.

Large woody material and fine organic matter amounts (except when needed for essential erosion control) may be reduced to meet fuel management objectives in strategic fuel treatment areas, on fuel breaks, and in other critical areas. Evaluate or monitor soil nutrient status in fuel treatment areas and other areas that lack sufficient large woody material and fine organic matter.

(d) Soil Moisture Regime is unchanged where productivity or potential natural plant communities are dependent upon specific soil drainage classes. Use natural soil drainage classes to evaluate the effect of management induced watertable or subsurface flow changes on plant growth or potential plant community composition.

Soil Hydrologic Function

To avoid accelerated surface runoff, infiltration and permeability are not reduced to ratings of 6 or 8 as defined in Region 5 Erosion Hazard Rating system (R-5 FSH 2509.22, Ch. 50).

Soil Buffering Capacity

Materials added to the soil must not alter soil reaction class, buffering or exchange capacities, or microorganism populations to the degree that significantly affects soil productivity, bioremediation potential, soil hydrologic function, or the health of humans or animals.

Develop local threshold values as the need arises and submit to the Regional Forester for standardization among forests.

Assumptions and Methodology

The following question and assumptions were used to evaluate the effects of each alternative:
1. Would the Action Alternative increase or decrease direct soil disturbance compared to present management?

The effects of mechanical treatments on soils are primarily associated with the type of treatment and the frequency and extent of disturbance" (Helms and Tappeiner 1996). Cumulative impacts of direct soil disturbance were assumed to pose a greater risk to soil quality than high intensity wildfire primarily because of the larger number of acres that has been impacted by management. The type of equipment used can make a difference for soil quality. Newer methods of timber harvest and slash treatment are being used in some areas, significantly reducing impacts to soil quality. However, assumes that conventional equipment would be used for management practices because that is what is available and being used currently in this area.

If intensive and frequent ground-based mechanical treatments were expected to occur in a land allocation, the risk to soil quality was rated higher ("more risk"). For instance, in the urban wildland intermix zone, mechanical fuels treatments would be used to reduce fire hazards. The intensity and frequency of these treatments would be expected to impact soil quality over time so this allocation was rated "more risk."

Measures or Factors Used to Assess Environmental Consequences

Each alternative proposes a range of management activities that could impact soil to varying degrees. Additionally, each alternative would also influence the degree to which natural disturbance events, such as wildfire, could affect soil. Risk assessment was used to analyze the effects of the action alternatives. Risks to long-term soil productivity were compared under each alternative's proposed management and level of prescribed and natural fire. The acres of different kinds of possible soil disturbance were also considered in the final evaluation.

Quantified data about detailed existing soil conditions within the Monument is lacking for this analysis. Therefore, the risk assessment for soil effects relies on assumptions of what is expected to generally occur. Each type of soil disturbance was evaluated for its potential to cause detrimental effects to soil productivity, soil hydrologic function, and soil buffering capacity as well as the relative extent of the effect. Two events or effects pose the greatest risk to soil quality:

Management activities that can displace topsoil, reduce soil porosity (cause compaction), or reduce soil cover and increase erosion.

High intensity burn areas within wildfires that result in volatilization of soil nitrogen, loss of soil cover, and subsequent soil erosion.

Managing for long-term soil productivity requires balancing the risks of these two events. Some land disturbing treatments to reduce fuel buildups can result in compaction or erosion or interrupt nutrient cycling processes, but lethal wildfire may also result in severe erosion. Standards and Guidelines for soil quality have been developed to help manage risks from management activities and are listed above in Legal and Regulatory compliance.

Indirect Effects

The indirect effects of management practices on soil quality for a particular site depend on existing soil conditions and the extent to which soil characteristics are considered during project planning and implementation. The following section describes overall risks to soil quality based on the specific management direction and standards and guidelines proposed for each alternative. The relative risk to soil quality from proposed management is based mainly on (1) the amount of soil disturbance that management activities could create, and (2) whether management would increase or decrease the effects of wildfire on soil quality.

Each alternative proposes a range of management activities that could impact soil to varying degrees. The predominant silvicultural activity is thinning from below or the harvest of smaller, often suppressed understory trees, to reduce fuel loading and the risk of fire spreading into the crowns of larger overstory trees. Ground-based logging systems such as crawler tractors, rubber tired skidders, and feller-bunchers, are typically used in harvest operations; cut-to-length harvesting systems are sometimes used. Slash treatments may include no treatment, underburning, or mechanical treatment. Effects on soil from these activities can be variable, depending on the equipment used, soil characteristics such as depth and clay content, soil moisture when the activity occurs, and volume of woody material removed. Another management activity that varies across the alternatives is prescribed burning. Prescribed burning by definition is implemented during times when environmental conditions create moderate fire behavior. As such, the important effect of prescribed burning is its effect on fuel structure and future wildfire intensity.

Each alternative would also influence the degree to which natural disturbance events, such as wildfire, could affect soil. High-intensity wildfire ratings can indicate that (1) most of the duff has been consumed and a white or reddish ash remains, and (2) more than 80 percent of the forest canopy has been consumed. The loss of the duff layer (soil cover) is the dominant factor affecting soil erosion potential. A high-intensity burn can also damage the surface soil structure and create hydrophobic layers, further increasing potential erosion risk.

Activities Impacting Soil Productivity and Conservation

Wildfire is a natural component in the development of soils; it affects physical, chemical, and biological soil properties. Changes in these soil properties can result in beneficial or adverse changes to soil productivity depending on fire intensity, scale, duration, site history, and soil type. Low intensity fires tend to aid in nutrient cycling, while high-intensity fires can lead to volatilization of soil nitrogen and sulfur. Volatilization of fine organic matter increases soil erosion potential by reducing organic soil cover, creating water repellent soil layers, and changing soil structure. Wildfires can occur over large areas, sometimes spanning multiple watersheds. The impacts of severe wildfires pose one of the greatest risks to soil productivity in the Sierra Nevada.

Prescribed fire can be designed to minimize impacts on soil properties in thinned stands when fuel loadings are relatively low. However, in areas with high stand density or where existing fuel levels are high, mechanical treatments are often necessary prior to burning to meet prescribed fire and soil resource objectives.

Historically affected areas often include dense stands with heavy surface fuels where soils have been compacted from multiple entries, or large plantations located in previously burned areas. Such areas are highly susceptible to damage from ground-based equipment, and the principal risk to soil productivity is through detrimental compaction. These areas may also have the greatest need for fuels treatments as well as opportunities for soil restoration. As a result, an assessment of mechanized treatment, prescribed burning, and the potential risks of wildfire needs to be conducted, resulting in mitigation measures that would minimize impacts and/or maximize restoration of soil potential in previously impacted areas.

The Effects of Mechanical Treatments on Soils

Ecological restoration and fuels operations using mechanical means include a variety of techniques. They range, in order of increasing impacts to soils, from helicopter, to skyline cable, to ground-based operations over snow or frozen soils, to hand-felling with tractor skidding. Currently the primary technique used is mechanized harvest and mechanical fuel treatment using ground-based equipment. The principal risk to soil productivity is detrimental compaction from these operations. Managing the soil resource requires identifying the risks of using mechanical equipment and prescribing mitigation measures to avoid impacts to long-term soil productivity.

The effects of mechanical treatments on soils are primarily associated with the type of treatment and the frequency and extent of disturbance (Helms and Tappeiner 1996). Cumulative impacts of direct soil disturbance were assumed to pose a greater risk to soil quality than high-intensity wildfire primarily because of the larger number of acres that have been impacted by management. The type of equipment used can make a difference for soil quality. Newer methods of timber harvest and slash treatment are being used in some areas, significantly reducing impacts to soil quality. However, it is likely that conventional equipment would be used for management practices in the Monument because that is what is available and is currently being used in this area.

If intensive and frequent ground-based mechanical treatments were expected to occur in certain land allocations, the risk to soil quality was rated higher (more risk). For instance, in the wildland urban intermix (WUI) zone, mechanical fuels treatments would be used to reduce fire hazards. The intensity and frequency of these treatments would be expected to impact soil quality over time, so this allocation was rated as higher risk.

Effects by Alternative

Acres of Annual Mechanical Treatments and Placement of Treatments on the Landscape

Acres of mechanical treatments each year would likely be the highest under Alternatives E and F. Alternatives A and B would likely have an intermediate number of acres of mechanical treatments, and thus an intermediate level of risk. Alternatives C and D would likely treat fewer acres annually; hence, these alternatives would have less risk from mechanical treatments than Alternatives E and F. Alternatives C and D would mechanically treat the fewest acres; thus, impacts to soil conservation and productivity directly attributable to mechanical treatments would be lowest under these alternatives. However, even Alternative E treats less than 1 percent of the planning area each year so, with the implementation of soil standards and guidelines, the overall risk from implementation of all action alternatives is low.

Additionally, Alternatives A, B, E, and F would have the greatest number of acres in the wildland urban intermix, where mechanical fuel treatments would be encouraged and concentrated. Alternatives C and D would have much less acreage in wildland urban intermix.

Acres of Annual Prescribed Fire

According to the SPECTRUM model, Alternative B would likely treat the greatest number of acres using prescribed fire, followed by Alternatives E and F. Alternatives A and C would have intermediate levels of prescribed burning. Alternative D would have the lowest number of acres of prescribed fire. Prescribed burning activities in Alternative B would therefore have the greatest effect on reducing surface fuel loads and future wildfire intensity. The beneficial effect of prescribed fire of soils would be highest under Alternative B and lowest under Alternative D. However, even Alternative B treats less than 1 percent of the planning area each year, so the overall difference in beneficial effects between the alternatives would be small.

Relative Risk of Wildfire (Wildfire Acres Projected to Burn Annually at Lethal Severity)

Alternatives C and D would have the greatest risk for large, severe wildfires (with more acres of lethal severity) that could lead to increases in soil erosion, as compared to the no action alternative. Alternatives B, E, and F would reduce the projected number of acres burned by wildfire relative to what is projected for Alternative A. However, as above the quantitative differences between the alternatives when it comes to wildfire effects is small.

Cumulative Effects

The management prescriptions for the Monument outlined in the draft EIS, cover all aspects of management of soils (vegetation treatments, fire, recreation, roads). Cumulative effects on soils (those effects not directly in the plan) would mostly likely come from outside the Monument. The only potential effect from outside the Monument would be climate and climate change projections for the Monument include: increasing temperatures; precipitation falling increasingly as rain instead of snow, leading to decreasing snowpack; and summers that are longer and drier. Forest vegetation types are predicted to migrate to higher elevations as warmer temperatures make those areas suitable for colonization and survival. The combination of warmer climate with higher CO_2 fertilization will likely increase fuel loads, leading to more frequent and intense fires throughout western North America.

The precise cumulative effects of climate change on soil productivity are difficult to predict and will not be addressed in this analysis.(1)

1 For a more detailed description of how climate change may impact the Monument in general, see the effects on air resources section in chapter 4 and Appendix C of the draft EIS.

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