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Coconino National Forest

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Soils Specialist Report

Forest Plan Revision DEIS

Submitted by: __/s/ _____
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Preface

The information in this specialist report reflects analysis that was completed prior to and in conjunction with the completion of the Draft Environmental Impact Statement (DEIS) for the revision of the 1987 Coconino National Forest Land Management Plan (the Plan). The primary purpose of specialist reports associated with the DEIS is to provide detailed information to assist in the preparation of the DEIS. As the DEIS was prepared, review-driven edits to the broader DEIS resulted in modifications to some of the information contained in some of the specialist reports. As a result, some reports no longer contain information and analysis that was updated through an interdisciplinary review process and is included in the DEIS in its entirety. This is a complete specialist report which includes all the information that was summarized in the DEIS and other supplemental information. Efforts have been made to ensure that the retained information in the specialist reports is consistent with the DEIS. If inconsistencies exist between specialist reports and the DEIS, the DEIS should be regarded as the most current, accurate source of analysis.

Executive Summary

Affected Environment:

Forestwide Soil Condition: Historically, most areas on the Forest (89%) are inferred to have been in satisfactory soil condition and about 11% of the areas were inherently unstable. Currently, about 62% of the soils are in satisfactory soil condition, about 20% are impaired, about 7% are in unsatisfactory condition, and about 11% are inherently unstable. Human disturbances during the last 100 – 125 years are believed to have caused impacts and declines in soil condition (USDA Forest Service 2009). Major disturbances that were absent historically include: livestock and elk herbivory, vegetative treatments, dispersed recreational and off highway vehicle use, and establishment and use of roads and trails. Fire is a disturbance that existed historically, but is now largely absent at past frequencies and severities. Historic fire regimes maintained many portions of the Ponderosa Pine and Piñon Juniper (PJ) Evergreen Shrub Potential Natural Vegetation Types (PNVTs) in open stands with more herbaceous understory and protective litter. Recent drought conditions have contributed to reduced vegetative growth and ineffective ground cover.

Soil Conditions by PNVT

Overall, about 27 percent of the soils, are classified as being impaired or unsatisfactory. These vegetation types are Montane Subalpine Grassland, Wetland/Cienega, Pinyon Juniper with Grass, PJ Woodland (Persistent), Pinyon Juniper Evergreen Shrub, Great Basin Grassland, Semi-Desert Grassland, Cottonwood Willow Riparian Forest, and Desert Communities. This means that there is a reduction or loss of soil function in these types and ecological functions and soil productivity will not be maintained.

Soil is mainly in satisfactory condition in Ponderosa Pine, Mixed Conifer types and Spruce Fir, Mixed Broadleaf Deciduous Riparian Forest, and Montane Willow Riparian Forest.

Soil is mainly in satisfactory, but inherently unstable condition in both Alpine Tundra and Interior Chaparral PNVTs. These soils are located on very steep slopes where natural erosion rates exceed tolerable rates and are eroding faster than they are renewing themselves, but are functioning properly and normally.

All PNVTs except Montane Subalpine Grassland and Ponderosa Pine contain inherently unstable soils. All of Alpine Tundra and more than 88 percent of Interior Chaparral acres are considered inherently unstable. Around 28 percent of the acres in Semi-Desert Grassland and Pinyon Juniper Evergreen Shrub PNVTs fall into this category while the remaining PNVTs have 10 percent or less of their acres in this condition.

The Coconino has experienced multiple years of drought since about 1997. This has resulted in reduced upland vegetative growth and ineffective ground cover, putting the soil at risk of accelerated erosion, loss of soil productivity, and increasing sediment delivery to streams during storm events causing local water quality degradation.

About 27% percent of the soils on the Forest are departed (unsatisfactory or impaired, see table 1). These departures indicate a reduction or loss in soil function and the possibility that they may not be able to sustain ecological functions and soil productivity.

Environmental Consequences (Forest-wide)

Forestwide desired conditions are equivalent to reference conditions for this resource. Plan language under all alternatives directs implementing site-specific best management practices (BMPs) for ground disturbing projects.

Management of soil resources would continue in accordance with direction in the 1987 Forest Plan (as amended). Current plan direction to maintain or enhance soil productivity and put all areas forest-wide in satisfactory condition by 2020 is unrealistic, vague or unattainable under current budget authority and would be difficult to achieve at the PNVT scale too. About 27% of forest or nearly 500,000 acres are still not in satisfactory condition.

Forest-wide desired conditions and guidelines are fairly similar under all alternatives except alternatives B, C and D provide additional soil and PNVT specific desired conditions focusing on sustaining soil function including resisting erosion, compaction and sustaining soil nutrient cycling . For example, alternative A does not recognize the importance of protecting soil crusts to maintain soil productivity while alternatives B, C, and D provide a description of desired conditions for soil crusts. Implementing this direction should result in better protection of soil crusts necessary to maintain soil productivity compared to alternative A.

Attaining these outcomes would require managing human and natural disturbances including managing towards proper tree densities and allowing natural disturbances to play a role especially in fire adapted ecosystems.

Current plan rate of implementation for soil treatment including maintenance, protection and improvement over last 10 years is about 20,000 acres/yr. These treatments do not target only those soils that are not is satisfactory condition but include soils in all conditions. At this rate, only about 11% of soils could be treated on an opportunity basis and not target specific PNVTS or soils not in satisfactory condition needed improvement. Even if all treatments were focused on soils not in satisfactory condition, it would take about 25 years to improve all to satisfactory condition and plan life is about 15 years. Under alternatives B, C and D, between 5 – 20% of all soils would be treated (maintenance, protection or improvement) and up to about 70% of impaired and unsatisfactory soils could be treated targeting soils and PNVTs that have the greatest need for improvement. The least potential for improvement to soils is through Alternative A.

Implementing plan direction in alternatives B, C, and D have the greatest potential to improve soil condition and productivity and move towards desired condition for most PNVTs but rate is variable (5-20%) based on predicted implementation of plan components including objectives. Implementing more than 11% would be an improvement compared to alternative A. This is a higher rate of improvement than alternative A.

There are no measurable differences among alternatives B, C, and D in plan components or anticipated outcomes for soil improvement. The primary differences between alternative A versus B, C, and D are added emphasis on managing or treating specific PNVTs and increases in upland soil and watershed improvement projects, and in road naturalization and decommissioning. This would improve soil condition and long-term soil productivity faster in alternatives B, C, and D than in alternative A.

Although alternatives B, C, and D differ in plan direction, such as the number of recommended wilderness, areas with semiprimitive nonmotorized recreation settings, wildlife habitat management areas, and allowance of mechanized recreation in botanical and geological areas,

soil condition, function, and productivity are not expected to differ substantially between these alternatives.

The primary differences between alternative A versus B, C, and D are added emphasis on managing or treating specific PNVTs and increases in upland soil and watershed improvement projects, and in road naturalization and decommissioning. This would improve soil condition and long-term soil productivity faster in alternatives B, C, and D than in alternative A.

Overall, and for most PNVTs, implementing direction in alternatives B, C, and D would equally move or improve soil condition and productivity and at a rate faster than alternative A. Table 2 and 3 details estimated trends toward identified desired conditions by PNVT.

Alternative C

Alternative C is similar to B and D, except it recommends 13 new wilderness areas, 8 additional management areas for wildlife habitat, reduces the amount of designated roads, restricts grazing in RNAs, designates some areas as not suitable for recreational shooting and designates some management areas as semi-primitive non-motorized. Compared to alternatives B and D, implementing direction in alternative C plan direction would probably result in similar improvement in soil condition and productivity as Alternatives B and D. In WHMAs, with fewer roads designated, existing closed roads would begin to revegetate, heal and trap soil that otherwise would be delivered downstream to connected waters. Consequently, there would be less sediment delivery into connected streamcourses over time (within 5 years), water quality downstream would improve slightly and be better protected than other alternatives in areas downstream of WHMAs. Also, grazing would continue in the recommended wilderness areas under alternative C, so there would be no improvement to soils from changes in grazing. Therefore, predicted soil improvement would be similar to alternatives B and D.

Detailed analysis by PNVT can be found in the body of this report.

Contents

Introduction

This specialist report evaluates and discloses the potential environmental consequences on the soil resources that may result with the adoption of a revised land management plan. It examines, in detail, four different alternatives for revising the 1987 Coconino National Forest Land Management Plan (1987 Plan).

Relevant Laws, Regulations, and Policy that Apply

All alternatives are designed to guide the Coconino NF's management activities in meeting all applicable Federal and State laws, regulations, and policies

Bankhead-Jones Farm Tenant Act of July 22, 1937 - Directed the Secretary of Agriculture to develop a program of land conservation and utilization in order to correct maladjustments in land use and thus assist in such things as control of soil erosion, reforestation, preservation of natural resources, and protection of fish and wildlife.

Clean Water Act (see Federal Water Pollution Control Act)

Emergency Flood Prevention (Agricultural Credit Act) Act of August 4, 1978 - Authorizes the Secretary of Agriculture to undertake emergency measures for runoff retardation and soil-erosion prevention, in cooperation with land owners and users, as the Secretary deems necessary to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood, or other natural occurrence is causing or has caused a sudden impairment of that watershed.

Federal Land Policy and Management Act of October 21, 1976 - Requires that public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use. Also states that the United States shall receive fair market value of the use of the public lands and their resources unless otherwise provided for by law.

Federal-State Cooperation for Soil Conservation Act of December 22, 1944 - Authorized the adoption of eleven watershed improvement programs in various states for the improvement of water runoff, water flow retardation, and soil erosion prevention.

Federal Water Pollution Control Act and Amendments of 1972 (Clean Water Act) - Enacted to restore and maintain the chemical, physical, and ecological integrity of the Nation's waters. Provides for measures to prevent, reduce, and eliminate water pollution; recognizes, preserves, and protects the responsibilities and rights of States to prevent, reduce, and eliminate pollution, and to plan the development and use (including restoration, preservation, and enhancement) of land and water resources; and provides for Federal support and aid of research relating to the

prevention, reduction, and elimination of pollution, and Federal technical services and financial aid to state and interstate agencies and municipalities for the prevention, reduction, and elimination of pollution.

Established goals for the elimination of water pollution; required all municipal and industrial wastewater to be treated before being discharged into waterways; increased Federal assistance for municipal treatment plant construction; strengthened and streamlined enforcement policies; and expanded the Federal role while retaining the responsibility of States for day-to-day implementation of the law.

Federal Water Project Recreation Act of July 9, 1965 - Requires that recreation and fish and wildlife enhancement opportunities be considered in the planning and development of Federal water development.

Forest and Rangeland Renewable Resources Planning Act of August 17, 1974 - Directs the Secretary of Agriculture to prepare a Renewable Resource Assessment every ten years; to transmit a recommended Renewable Resources Program to the President every five years; to develop, maintain, and, as appropriate, revise land and resource management plans for units of the National Forest System; and to ensure that the development and administration of the resources of the National Forest System are in full accord with the concepts of multiple use and sustained yield.

Healthy Forests Restoration Act of 2003 (H.R. 1904) - Purposes are to reduce wildfire risk to communities and municipal water supplies through collaborative hazardous fuels reduction projects; to assess and reduce the risk of catastrophic fire or insect or disease infestation; to enhance efforts to protect watersheds and address threats to forest and rangeland health (including wildfire) across the landscape; to protect, restore, and enhance forest ecosystem components such as biological diversity, threatened/endangered species habitats, enhanced productivity.

Joint Surveys of Watershed Areas Act of September 5, 1962 - Authorizes and directs the Secretaries of the Army and Agriculture to make joint investigations and surveys of watershed areas in the United States, Puerto Rico, and the Virgin Islands, and to prepare joint reports setting forth their recommendations for improvements needed for flood prevention, for the conservation, development, utilization, and disposal of water, and for flood control.

Knutson-Vandenberg Act of June 9, 1930 -Authorizes the Secretary of Agriculture to establish forest tree nurseries; to deposit monies from timber sale purchasers to cover the costs of planting young trees, sowing seed, removing undesirable trees or other growth, and protecting and improving the future productivity of the land; and to furnish seedlings and/or young trees for the replanting of burned-over areas in any National Park.

Land and Water Conservation Fund Act of September 3, 1964 - Authorizes the appropriation of funds for Federal assistance to States in planning, acquisition, and development of needed land and water areas and facilities and for the Federal acquisition and development of certain lands and other areas for the purposes of preserving, developing, and assuring accessibility to outdoor recreation resources.

The National Environmental Policy Act of 1969 - This act declares a national policy that encourages productive and enjoyable harmony between people and their environment, promotes

efforts that will prevent or eliminate damage to the environment and biosphere, and enriches the understanding of the ecological systems and natural resources important to the nation.

National Forest Management Act of October 22, 1976 - The National Forest Management Act reorganized, expanded, and otherwise amended the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for the management of renewable resources on National Forest System lands. The National Forest Management Act requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the National Forest System. It is the primary statute governing the administration of National Forests.

National Forest Roads and Trails Act of October 13, 1964 - Authorizes the Secretary of Agriculture to provide for the acquisition, construction, and maintenance of forest development roads within and near the National Forests through the use of appropriated funds, deposits from timber sale purchasers, cooperative financing with other public agencies, or a combination of these methods. The Act also authorizes the Secretary to grant rights-of-way and easements over National Forest System lands.

Organic Administration Act of June 4, 1897 - Authorizes the President to modify or revoke any instrument creating a national forest; states that no national forest may be established except to improve and protect the forest within its boundaries, for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States. Authorizes the Secretary of Agriculture to promulgate rules and regulations to regulate the use and occupancy of the national forests.

Multiple-Use Sustained-Yield Act of June 12, 1960 - States that it is the policy of Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes, and authorizes and directs the Secretary of Agriculture to develop and administer the renewable surface resources of the national forests for the multiple use and sustained yield of products and services.

Mining and Minerals Policy Act of December 31, 1970 - States that it is the policy of the Federal government to foster and encourage the development of economically sound and stable domestic mining, minerals, metal, and mineral reclamation industries; the orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of industrial, security, and environmental needs; mining, mineral, and metallurgical research to promote the wise and efficient use of our natural and reclaimable mineral resources; and the study and development of methods for the disposal, control, and reclamation of mineral waste products and the reclamation of mined land.

National Environmental Policy Act of January 1, 1970 - Directs all Federal agencies to consider and report the potential environmental impacts of proposed Federal actions, and established the Council on Environmental Quality.

National Forest Management Act of October 22, 1976 - The National Forest Management Act reorganized, expanded, and otherwise amended the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for the management of renewable resources on National Forest System lands. The National Forest Management Act requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield

principles, and implement a resource management plan for each unit of the National Forest System. It is the primary statute governing the administration of National Forests.

Safe Drinking Water Amendments of November 18, 1977 - Amended the Safe Drinking Water Act to authorize appropriations for research conducted by the Environmental Protection Agency relating to safe drinking water; Federal grants to states for public water system supervision programs and underground water source protection programs; and grants to assist special studies relating to the provision of a safe supply of drinking water.

Sikes Act of October 18, 1974, as amended - This Act authorizes the Forest Service to cooperate with state wildlife agencies in conservation and rehabilitation programs for fish, wildlife, and plants considered threatened or endangered.

Soil and Water Resources Conservation Act of November 18, 1977 - Provides for a continuing appraisal of the United States' soil, water and related resources, including fish and wildlife habitats, and a soil and water conservation program to assist landowners and land users in furthering soil and water conservation.

Surface Mining Control and Reclamation Act of August 3, 1977 - Authorizes the Secretary of Agriculture to enter into agreements with landowners, providing for land stabilization, erosion, and sediment control, and reclamation through conservation treatment, including measures for the conservation and development of soil, water, woodland, wildlife, and recreation resources, and agricultural productivity of such lands.

Travel Management Rule - On December 9, 2005, the Forest Service published the TMR. The agency rewrote direction for motor vehicle use on National Forest Service (NFS) lands under 36 CFR, Parts 212, 251, and 261, and eliminated 36 CFR 295. The rule was written to address at least in part the issue of unmanaged recreation. The rule provides guidance to the Forest Service on how to designate and manage motorized recreation on the Forests. The rule requires each National Forest and Grassland to designate those roads, motorized trails, and Areas that are open to motor vehicle use.

U.S. Mining Laws (Public Domain Lands) Act of May 10, 1872 - Provides that all valuable mineral deposits in lands belonging to the United States, both surveyed and unsurveyed, are free and open to exploration and purchase, and the lands in which they are found to occupation and purchase by citizens of the United States and those who have declared their intention to become such, under regulations prescribed by law, and according to the local customs or rules of miners, so far as the same are applicable and not inconsistent with the laws of the United States. There are a number of Acts which modify the mining laws as applied to local areas by prohibiting entry altogether or by limiting or restricting the use which may be made of the surface and the right, title, or interest which may pass through patent.

Water Quality Improvement Act of April 3, 1970 - Amends the prohibitions of oil discharges, authorizes the President to determine quantities of oil which would be harmful to the public health or welfare of the United States; to publish a National Contingency Plan to provide for coordinated action to minimize damage from oil discharges. Requires performance standards for marine sanitation device and authorizes demonstration projects to control acid or other mine pollution, and to control water pollution within the watersheds of the Great Lakes. Requires that applicants for Federal permits for activities involving discharges into navigable waters provide state certification that they will not violate applicable water quality standards

Water Resources Planning Act of July 22, 1965 - Encourages the conservation, development, and utilization of water and related land resources of the United States on a comprehensive and coordinated basis by the Federal government, states, localities, and private enterprises.

Watershed Protection and Flood Prevention Act of August 4, 1954 - Establishes policy that the Federal government should cooperate with states and their political subdivisions, soil or water conservation districts, flood prevention or control districts, and other local public agencies for the purposes of preventing erosion, floodwater, and sediment damages in the watersheds of the rivers and streams of the United States; furthering the conservation, development, utilization, and disposal of water, and the conservation and utilization of land; and thereby preserving, protecting, and improving the Nation's land and water resources and the quality of the environment.

Regulations

Below is a partial listing of relevant regulations. Federal executive departments and administrative agencies write regulations to implement laws. Regulations are secondary to law. However, both laws and regulations are enforceable.

33 CFR 323 Permits for Discharges of Dredged or Fill Material into Waters of the United States - This regulation prescribes those special policies, practices and procedures to be followed by the Corps of Engineers in connection with the review of applications for permits to authorize the discharge of dredged or fill material into waters of the United States.

36 CFR 212.5 (b) Roads - ...the responsible official must identify the minimum road system needed for safe and efficient travel and for administration, utilization, and protection of National Forest System lands. ... The minimum system is the road system determined to be needed to meet resource and other management objectives adopted in the relevant land and resource management plan (36 CFR 219), to meet applicable statutory and regulatory requirements, to reflect long-term funding expectations, to ensure that the identified system minimizes adverse environmental impacts associated with road construction, reconstruction, decommissioning, and maintenance.

Identification of unneeded roads. Responsible officials must review the road system on each National Forest and Grassland and identify the roads on lands under Forest Service jurisdiction that are no longer needed to meet forest resource management objectives and that, therefore, should be decommissioned or considered for other uses, such as for motorized routes.

Regional Forester’s direction: Roads analysis process (RAP) for all other existing roads should be completed in conjunction with implementation of the off-highway vehicle (OHV) Record of Decision, watershed analyses, other project level activities or Forest Plan revisions.

Travel Management Rule - On December 9, 2005, the Forest Service published the TMR. The agency rewrote direction for motor vehicle use on National Forest Service (NFS) lands under 36 CFR, Parts 212, 251, and 261, and eliminated 36 CFR 295. The rule was written to address at least in part the issue of unmanaged recreation. The rule provides guidance to the Forest Service on how to designate and manage motorized recreation on the Forests. The rule requires each National Forest and Grassland to designate those roads, motorized trails, and Areas that are open to motor vehicle use.

36 CFR 219 Planning - Sets forth a process for developing, adopting, and revising land and resource management plans for the National Forest System.

36 CFR 241 Fish and Wildlife - Sets forth the rules and procedures relating to the management, conservation, and protection of fish and wildlife resources on National Forest System lands.

40 CFR 121-135 Water Programs - Sets forth the provisions for the administration of water programs including: state certification of activities requiring a Federal license or permit; EPA administered permit programs; state program requirements; procedures for decision making; criteria and standards for the National Pollutant Discharge Elimination System; toxic pollutant effluent standards; water quality planning and management; water quality standards; water quality guidance for the Great Lakes System; secondary treatment regulation; and, prior notice of citizen suits. See Title 40 (Protection of Environment), Chapter 1 (Environmental Protection Agency), subchapter D (Water Programs).

40 CFR 1500 Council on Environmental Quality - Council on Environmental Quality regulations implementing the National Environmental Policy Act.

Executive Orders

Below is a partial listing of relevant executive orders. Executive orders are official documents by which the President provides instructions to executive departments and agencies. An executive order may be used to reassign functions among executive branch agencies. It may adopt guidelines, rules of conduct, or rules of procedure for government employees or units of government. It can also establish an advisory body or task force.

EO 11988 Floodplain Management, 1977 - Requires each Federal agency to provide leadership and to take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for acquiring, managing, and disposing of Federal lands and facilities; providing federally undertaken, financed, or assisted construction and improvements; and conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

EO 11990 Protection of Wetlands, 1977 - Requires each Federal agency to provide leadership and to take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for acquiring, managing, and disposing of Federal lands and facilities; providing federally undertaken, financed, or assisted construction and improvements; and conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Policy

The Forest Service Manual (FSM) contains legal authorities, goals, objectives, policies, responsibilities, instructions, and the necessary guidance to plan and execute assigned programs and activities.

Forest Service Handbooks (FSH) are directives that provide instructions and guidance on how to proceed with a specialized phase of a program or activity. Handbooks either are based on a part of the FSM or they incorporate external directives.

FSM 2500 Watershed and Air Management

- **FSM 2520** Watershed Protection and Management
    - FSH 2509.25 Watershed Conservation Practices Handbook, Southwestern Region
- **FSM 2540** Water Uses and Development, Southwestern Region supplement

FSM 7700 Transportation System

- **FSM 7710** Travel Planning
    - FSH 7709.55 Travel Analysis
    - FSH 7709.56 Chapter 2 – Road Location

FSH 2509.22 (Soil and Water Conservation Practices Handbook) and Draft **FSH 2509.25** when finalized, or more current guidance.

Best management practices to control nonpoint source pollution for ground disturbing activities should be mitigated through identification and implementation of best management practices identified by the interdisciplinary team and guided by FSH 2509.22 (Forest Service, 1990)

Intergovernmental Agreements

Intergovernmental Agreement 16-R3-91-033 between the State of Arizona Department of Environmental Quality and the USDA Forest Service SW Region.

To respond to the objectives defined by Congress in the Federal Water Pollution Control Act, as amended (1987). This objective is to restore and maintain the chemical, physical and biological integrity of the nation's waters in Arizona by attaining the goal of water quality which provides for the protection and propagation of fish, and wildlife, and provides for safe recreation in and on the waters of the State of Arizona;

To manage all resources and operate all programs for which they are responsible in a manner that seeks to achieve federal water quality goals and state water quality standards;

That the most practical and effective means of controlling potential nonpoint pollution sources from forests and rangelands is through development of preventative or mitigating land management practices, generally referred to as Best Management Practices (BMP's), and to ensure control of such nonpoint sources through the implementation of BMP's;3.To develop and implement procedural methods to minimize duplication of effort and facilitate complementary nonpoint source pollution control and abatement programs;

To jointly identify existing or potential nonpoint source pollution problems on National Forest System lands. To designate the Forest Service as the designated Planning and Management

Agency for National Forest System lands within the context of the Arizona Water Quality Management Program pursuant to Section 208.

Methodology and Analysis Process

Methods

This section describes the methodology and analysis processes used to determine the environmental consequences on soil condition and productivity from implementing the alternatives. Environmental consequences are not site-specific at the broad forest planning level and will be described with qualitative descriptions supported by past studies and observations. Much of the background information is found in the Ecological Sustainability Report (ESR) (USDA Forest Service2009a) and the supporting specialist reports.

This qualitative analysis describes the current soil condition and productivity departures (historic to current) and projected trends in soil condition by alternative. It also describes the potential effects associated with management activities that could affect soil condition.

Soil condition is an evaluation of soil quality based on an interpretation of factors which affect vital soil functions and is based on the primary soil functions of soil hydrology, soil stability, and nutrient cycling as described by R3 Supplement FSH 2509.18, (1991, 2012). The current soil condition rating is described in the Ecological Sustainability Report (USDA Forest Service 2009a) and was based on how departed soils are from the historic range of natural variability.

Soil productivity is a combination of soil organic matter, litter cover and estimated understory and forage production. Terrestrial Ecosystem Survey (TES) (USDA Forest Service, 1995) information was used to establish reference conditions for forage and litter production and current litter cover. TES was used to describe understory and forage production reference condition values and current values were estimated from field observations made Forest-wide (Forest Service, 2009). Organic matter thickness was derived from thickness of the organic surface horizon through soil classification (USDA Forest Service, 2009).

Departures levels in soil condition and productivity were identified as low, moderate, or high and are estimates comparing historic and current soil conditions (erosion, compaction, organic matter, litter cover, understory forage) based on acreage differences between current and historic soil condition by PNVT. Percent soils in satisfactory condition under reference conditions is the estimated amount of satisfactory soil conditions before human activities had major influences and disturbances on soil condition (i.e., Pre-European settlement) based on correlated Terrestrial Ecosystem Survey (TES) ecological reference sites.

No models currently exist to predict trends and future foreseeable conditions for soil resources, in particular, soil condition, soil productivity, or soil organic matter. However, qualitative inferences can be made and estimated providing insight into future soil conditions primarily using knowledge about present disturbances and their effect on erosion processes, soil compaction and nutrient cycling. Tables have been prepared to generally estimate trends and conditions using existing data and current conditions, combined with projected future vegetation conditions derived from the Forests' VDDT models. The VDDT models predict overall dominant vegetation condition and trends and describe relative amounts in each of the defined ecological states for

each Potential Natural Vegetation Type (PNVT) in the future (from 10 to 1,000 years). Dominant vegetation and tree density and canopy cover has an effect on ground cover conditions. Where mechanical treatments are proposed, herbaceous understory would improve along with soil condition. Therefore, predicted improvements in soil condition from implementing treatments modeled by VDDT are made. Each table keys on combinations of current departure (low, moderate and high) from the historic range of natural variability[1] for soil condition and productivity which includes soil organic matter, vegetative ground vegetation and plant composition and biomass productivity. Inferences of future conditions and trend are made based on current knowledge of how canopy cover (and ecological state) presently affects these key soil components.

Projected trends in soil condition and soil productivity are based on estimates of the relative change in soil erosion, soil compaction and soil nutrient cycling functions by alternative using vegetative ground cover and herbaceous understory as indicators to determine change to soil condition and productivity.

Each vegetation type was examined to see whether soil conditions would generally trend towards, away or remain static with the implementation of treatments by alternative. The analysis supports the Vegetative Dynamic Digital Tracking (VDDT) modeling results for each vegetation.

Microbiotic (biological) soil crusts have not been quantified in any detail. However, a qualitative summary may be useful in describing existing conditions and the ecological role of crusts in disturbed ecosystems. Since current composition and density of crusts have not be inventoried, we can only infer trends based on current and projected management impacts that have been shown in research to alter populations of crusts.

Assumptions

The land management plan provides a programmatic framework for future site-specific actions.

- Land management plans do not have direct effects. They do not authorize or mandate any site-specific projects or activities (including ground-disturbing actions).
- Land management plans may have implications, or environmental consequences, of managing the forests under a programmatic framework.
- The plan decisions (desired conditions, objectives, standards, guidelines, management areas, monitoring) will be followed when planning or implementing site-specific projects and activities.
- Laws, regulations, and policies will be followed when planning or implementing site-specific projects and activities.
- Monitoring will occur and the land management plan will be amended, as needed.

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[1] HRV is a description of the change over time and space in the ecological condition of potential natural vegetation types and the ecological processes that shape those types. In the forest plan revision process HRV is used as an ecological baseline or reference point as well as the Desired Condition (DC) in some vegetation types where primarily wildlife habitat needs modify the mix of desired states.

- We will be funded similar to past budget levels (past 5 years).
- The planning timeframe is 10 years; other timeframes may be analyzed depending on the resource (usually a discussion of anticipated trends into the future).
- For estimating the effects of alternatives at the programmatic forest plan level, the assumption has been made that the kinds of resource management activities allowed under the prescriptions will occur to the extent necessary to achieve the goals and objectives of each alternative. The actual location, design, and extent is not known at this time and will be a site specific (project by project) decision. Therefore this analysis refers to potential of the effect to occur, realizing that in many cases, these are only estimates. The effects analysis is useful in comparing and evaluating alternatives on a forestwide basis but is not to be applied to specific locations on the forests. Some resources are not within the Agencies ability to control; these will be noted.

Indicators used to compare alternatives

No soil resource key issues surfaced or were identified by the public. However, this analysis will disclose existing conditions and predict the indirect effect management direction would have by alternative on soil resources

Existing soil condition and productivity is assessed and projected trends in soil condition and soil productivity will be predicted by alternative and identified plan components.

They are based on estimates of the relative change in soil erosion, soil compaction and soil nutrient cycling functions by alternative using vegetative ground cover and herbaceous understory as indicators to determine change to soil condition and productivity.

Indicators Used: Change in soil condition and productivity trend by acres treated and ability to meet or move towards desired condition by implementing management direction by alternative.

Public comment did request soil information in tabular format displaying basic soil information from the TES including the 5 largest (in acres) soil types by habitat type and values for current/potential percents of rock fragments, bare soil, litter, vegetative basal area and overstory cover. Some of this information will be included in the appendix and others information will be tiered to existing documents.

Summary of Alternatives

A summary of alternatives, including the key differences among alternatives, is outlined in the Draft Environmental Impact Statement.

Four alternatives are analyzed in detail in this Specialist Report: Alternatives A through D. Alternative A is the current 1987 Coconino National Forest Plan (Forest Service, as amended, 1987), and Alternative B is the Preferred Alternative/Proposed Action, drafted over the past several months and refined with several tranches of internal and informal public feedback. Alternative C considers increases in the amount of wilderness and special areas, as well as increased opportunities for quiet semi-primitive recreation, while Alternative D considers slightly

fewer restrictions than Alternatives B and C on human access and use of the Forest and its resources.

- Alternative A is the “1987 Plan
- Alternative B is the “Proposed Revised Plan”
- Alternative C is “Alternative C”
- Alternative D is “Alternative D”

Management activities affecting the soil resource will be analyzed. Specifically, existing condition will be analyzed and effects of management actions on soil condition and productivity will be predicted by the ability to meet or move towards desired conditions (maintain or improve soil productivity) by extent or acres or percent.

Affected Environment

Introduction

This section summarizes current conditions and departures between current and reference conditions and associated trends, for soil condition, soil productivity and for biological soil crusts. More additional information on soils, departure and trend by PNVT, please see the ESR (USDA, 2009a), USDA 2009 and Forest Plan Revision Soils Specialist Report, (USDA, 2013).

Soils are a physical element of the environment made up of mineral particles (e.g., sand, silt, and clay), air, water, and organic matter. Soils form by the interaction between climate, organisms, topography, parent material, and time. Soils store water, supply nutrients for plants, and provide a medium for plant growth. Soils also provide habitat for a diverse number of below-ground organisms. Due to their slow rate of formation, soils are essentially a non-renewable resource.

Soils of the Coconino National Forest have developed primarily from volcanic and sedimentary origins. Soils range from very shallow to deep, old and well-developed to recent and less-developed, and occur on all slope ranges from nearly level to very steep. Elevations on the forests range from almost 12,667 feet in the San Francisco Peaks Alpine Tundra to less than 2,600 feet in the Verde Valley desert soils, which provides soil climate in upland soils ranging from cryic (cold) to thermic (hot) soil temperature regimes, and from udic (moist) to aridic (dry) soil moisture regimes. Herbage (i.e., herbaceous plant growth) productivity ranges from near 3,000 pounds per acre in the wettest areas, to less than 25 pounds per acre in the driest, raw cindery soils. Except for Alpine Tundra PNVT, PNVTs historically had mostly satisfactory soils. Departures from this reference condition are noted where they have deviated from historical or reference conditions.

The forests soils are described in the Terrestrial Ecosystem Survey of the Coconino NF (TES) (USDA Forest, Service, 1995). The TES is the result of the systematic analysis, mapping, classification and interpretation of terrestrial ecosystems, also known as ecological types, delineated and numbered in ecological units. It is the only seamless mapping of vegetation and soils available across the forests that includes field visited, validated and correlated sites with a stringent regional and national protocol stemming from decades of work. Major fieldwork for the

TES was completed during the period of 1987 through 1991. Soil names and descriptions were approved in 1992.

Soils of the Coconino NF have developed primarily from volcanic and sedimentary origins. Soils range from very shallow to deep, old and well-developed to recent and less-developed, and occur on all slope ranges from nearly level to very steep. The soil orders of Alfisols and Mollisols, as classified in Soil Taxonomy (USDA Forest Service, 1999), are common on the highly productive forest, woodland and grassland vegetation types. Inceptisols are commonly found in the less developed, younger and thin soils and commonly found on steep slopes on vocanic and sedimentary geologic types. Elevations on the forests range from almost 12,667 feet in the San Fransico Peaks Alpine Tundra to less than 2,600 feet in the Verde Valley desert soils, which provides soil climate in upland soils ranging from cryic (cold) to thermic (hot) soil temperature regimes, and from udic (moist) to aridic (dry) soil moisture regimes. Herbage productivity ranges from near 3,000 pounds per acre in the wettest areas, to less than 25 pounds per acre in the driest, raw cindery soils.

Past Management Impacts on Soil Condition

Historically (pre-European settlement) and without anthropogenic (man-caused) disturbances, soil loss, soil compaction and nutrient cycling would probably have been within functional limits to sustain soil function and maintain soil productivity for most soils that are not inherently unstable. The exception to this could be relatively short term effects of wildfire during times of drought. Since there were no political boundaries historically, soil condition would have been similar on similar soils throughout the range of the vegetation types both within and outside of the forests.

Much of the current soil condition is related to past management. Soils are affected by activities that occur or re-occur at the same place over time. Permanent loss of soil productivity has and could affect the level of future goods and beneficial use of the forests in the future. Management activities that have affected soil condition include timber harvesting, fires, roads, recreation, grazing, and special uses. Some examples of impacts that have affected current soil condition include:

- Heavily compacted soils from forest restoration treatments, grazing and recreation activities have caused or may cause reduced productivity for decades (Burger et.al 1998).
- Land disturbing activities caused erosion of topsoil at rates greater than the soils natural ability to replace it, commonly referred to as soil loss tolerance rate, resulting in permanent loss of soil productivity, as soils are considered a non-renewable resource (Renard, et al 1997b).
- Historically, more livestock numbers and acres were grazed, range condition (and soil condition) declined, and as fewer number and acres were grazed, range condition and trend improved.
- According to Gori et al. (2007) livestock and large wildlife grazing removed fine fuels needed to carry surface and mixed-severity fires that likely maintained the more open structure and composition of piñon-juniper savannas and shrub woodlands historically.

- Road corridors that make up the forests' road system resulted in loss of soil productivity.
- Mineral extraction pits and mines resulted in permanent loss or reduction in soil productivity.
- Uncharacteristic wildfire resulted in erosion rates well beyond tolerance erosion rates.
- Footprints of administration and recreation sites have reduced soil productivity.
- Permanent special use sites, such as communication towers and buildings eliminated soil productivity.

Forestwide Soil Condition

Historically, most areas on the Forest (89%) are inferred to have been in satisfactory soil condition and about 11% of the areas were inherently unstable. Currently, about 62% of the soils are in satisfactory soil condition, about 20% are impaired, about 7% are in unsatisfactory condition, and about 11% are inherently unstable. Human disturbances during the last 100 – 125 years are believed to have caused impacts and declines in soil condition (USDA Forest Service 2009). Major disturbances that were absent historically include: livestock and elk herbivory, vegetative treatments, dispersed recreational and off highway vehicle use, and establishment and use of roads and trails. Fire is a disturbance that existed historically, but is now largely absent at past frequencies and severities. Historic fire regimes maintained many portions of the Ponderosa Pine and Piñon Juniper Evergreen Shrub PNVTs in open stands with more herbaceous understory and protective litter.

Approximately 62 percent of the soils on the Forest are considered to be in satisfactory soil condition, about 20 percent are impaired, about 7 percent are in unsatisfactory condition, and about 11 percent are inherently unstable. Recent drought conditions have contributed to reduced vegetative growth and ineffective ground cover.

<u>Soil Conditions, departure and trends by PNVT</u>

- Overall, about 27 percent of the soils are classified as being impaired or unsatisfactory (table 1 and 2) compared to reference conditions. These vegetation types are Montane Subalpine Grassland, Wetland/Cienega, Pinyon Juniper with Grass, PJ Woodland (Persistent), Pinyon Juniper Evergreen Shrub, Great Basin Grassland, Semi-Desert Grassland, Cottonwood Willow Riparian Forest, and Desert Communities. This means that there is a reduction or loss of soil function in these types and ecological functions and soil productivity will not be maintained.
- Soil is mainly in satisfactory condition in Ponderosa Pine, Mixed Conifer types and Spruce Fir, Mixed Broadleaf Deciduous Riparian Forest, and Montane Willow Riparian Forest.

- Soil is mainly in satisfactory, but inherently unstable condition in both Alpine Tundra and Interior Chaparral PNVTs. These soils are located on very steep slopes where natural erosion rates exceed tolerable rates and are eroding faster than they are renewing themselves, but are functioning properly and normally. Most PNVTs contain inherently unstable soils. All of Alpine Tundra and more than 89 percent of Interior Chaparral acres are considered inherently unstable. Around 28 percent of the acres in Semi-Desert Grassland and Piñon Juniper Evergreen Shrub PNVTs fall into this category, while the remaining PNVTs have 10 percent or less of their acres in this condition. All PNVTs except Montane Subalpine Grassland and Ponderosa Pine contain inherently unstable soils.
- The Coconino has experienced multiple years of drought since about 1997. This has resulted in reduced upland vegetative growth and ineffective ground cover, putting the soil at risk of accelerated erosion, loss of soil productivity, and increasing sediment delivery to streams during storm events causing local water quality degradation.

Table1 illustrates that twenty seven percent of the soils on the Forest are departed (unsatisfactory and impaired). These departures indicate a reduction or loss in soil function and the possibility that they may not be able to sustain ecological functions and soil productivity.

Table 1. Acres and percent of acres of soil condition class by PNVT within lands managed by the Coconino National Forest

	Impaired		Satisfactory		Satisfactory, but inherently unstable		Unsatisfactory		
PNVT	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Percent**
Alpine or Tundra	0	0%	0	0%	939	100%	0	0%	100%
Cottonwood Willow Riparian Forest	2,423	97%	0	0%	56	2%	27	1%	100%
Desert Communities	24,172	38%	0	0%	34,595	54%	4,780	8%	100%
Gallery Coniferous Riparian Forest	1	0%	64	32%	135	68%	0	0%	100%
Great Basin Grassland	41,482	45%	12,512	13%	0	0%	38,915	42%	100%
Interior Chaparral	1	0%	5,406	11%	45,064	89%	0	0%	100%
Mixed Broadleaf Deciduous Riparian Forest	126	3%	3,224	89%	211	6%	51	1%	100%
Mixed Conifer with Aspen	0	0%	37,083	100%	0	0%	0	0%	100%
Mixed Conifer with Frequent Fire	15	0%	49,420	100%	185	0%	0	0%	100%
Montane Subalpine Grassland	16,178	69%	7,251	31%	0	0%	0	0%	100%
Montane Willow Riparian Forest	170	4%	2,959	77%	598	16%	101	3%	100%
Pinyon Juniper Evergreen Shrub	149,518	57%	20,330	8%	93,986	36%	0	0%	100%
Pinyon Juniper Grassland	45,105	17%	177,462	68%	10,346	4%	28,512	11%	100%
Pinyon Juniper Woodland (Persistent)	45,090	60%	21,324	28%	8,979	12%	0	0%	100%
Ponderosa Pine	27	0%	780,823	99%	4	0%	11,041	1%	100%
Semi-Desert Grassland	37,093	41%	4	0%	3,958	4%	48,629	54%	100%
Spruce Fir Forest	0	0%	12,622	91%	1,323	9%	0	0%	100%
Water	0	0%	0	86%	0	0%	0	14%	100%
Wetland or Cienega	1,112	36%	148	5%	0	0%	1,852	60%	100%
Grand Total	**362,512**	**20%**	**1,130,633**	**62%**	**200,379**	**11%**	**133,910**	**7%**	**100%**

Table 2. Current Soil Condition Departures and Trend from Reference by PNVT within lands managed by Coconino NF

PNVT	Total Acres	Soil condition class				Departure* and trend from reference condition
		Satisfactory	Satisfactory, but inherently unstable	Unsatisfactory	Impaired	
Cottonwood Willow Riparian Forest	2,507	0%	2%	1%	97%	High - slowly toward
Mixed Broadleaf Deciduous Riparian Forest	3,612	89%	6%	1%	3%	Low - static
Montane Willow Riparian Forest	3,829	77%	16%	3%	4%	Low - static
Gallery Coniferous Riparian Forest	200	32%	68%	0%	0%	Low - static
Desert Communities	63,548	0%	54%	8%	38%	Moderate - static
Semi-Desert Grassland	89,683	0%	4%	54%	41%	High - slowly toward
Great Basin Grassland	92,908	13%	0%	42%	45%	High - toward
Montane/Subalpine Grassland	23,429	31%	0%	0%	69%	High - static
Interior Chaparral	50,471	11%	89%	0%	0%	Low - static
Piñon Juniper with Grass	261,426	68%	4%	11%	17%	Low - away
Piñon Juniper Evergreen Shrub	263,834	8%	36%	0%	57%	Moderate - away
Piñon Juniper Woodland (Persistent)	75,393	28%	12%	0%	60%	Moderate - away
Ponderosa Pine	791,896	99%	0%	1%	0%	Low - static
Mixed Conifer with Frequent Fire	49,619	100%	0%	0%	0%	Low - static
Mixed Conifer with Aspen	37,083	100%	0%	0%	0%	Low - static
Spruce-Fir Forest	13,946	91%	9%	0%	0%	Low - static
Alpine or Tundra	939	0%	100%	0%	0%	Low - static

PNVT	Total Acres	Soil condition class				Departure* and trend from reference condition
		Satisfactory	Satisfactory, but inherently unstable	Unsatisfactory	Impaired	
Wetland/Cienega	3,112	5%	0%	60%	36%	High - static
Grand Total	1,827,434	62%	11%	7%	20%	

* Departure ratings from reference conditions: Low signifies ≤34% of the acres are in impaired or unsatisfactory condition. A moderate departure signifies a departure of 34%-66%, and high departure is a difference of ≥67%.

Table 2 information is derived from (USDA Forest Service, 2009) and updated in the ESR (USDA, 2009a).

Forest wide Soil Productivity

Productivity can vary widely within a PNVT based on the site potential. In general, **t**he most productive soils are within Montane Subalpine Grasslands and Wetland Cienega PNVTs followed by Great Basin Grassland. These soils have high amounts of organic matter and are capable of producing the greatest amount of understory and forage under conditions of the PNVT. Current understory and forage productivity appears to be low to moderate, and thus, could be improved.

Soil productivity is a combination of soil organic matter, litter cover and estimated understory and forage production. Soil productivity can vary widely within a PNVT based on the site potential. In general, the most productive soils are within Montane/Subalpine Grassland and Wetland/Cienega PNVTs followed by Great Basin Grassland. These soils have high amounts of organic matter and are capable of producing the greatest amount of understory and forage under conditions of the PNVT. Current understory and forage productivity, however, appears to be low to moderate.

The soils with the lowest productivity and lowest amount of organic matter are located in riparian forests (Cottonwood Willow Riparian Forest, Mixed Broadleaf Deciduous Riparian Forest, Mountain Willow Riparian Forest, Gallery Coniferous Forest), Desert Communities, and Alpine Tundra PNVTs. These PNVTs cannot be expected to produce high amounts of understory and forage because they have low amounts of surface organic matter due to dry climate or having been recently formed.

Piñon Juniper Woodland, Piñon Juniper Evergreen Shrub, and Ponderosa Pine PNVTs currently have low to moderate soil productivity (organic matter, and understory and forage production) but have the potential, based on reference condition, to become more productive and produce higher amounts of understory in areas with low cover. As cover decreases through fire, insect and drought outbreaks, or vegetative treatments, herbaceous understory and forage production are anticipated to increase.

Cottonwood Willow Riparian Forest

Reference Condition: Historically, the soil condition in this PNVT was mostly satisfactory. Soil productivity, however, was inherently low. Soils occur on both higher lying stream terraces and lower-lying floodplains in this PNVT, which naturally occurs in scattered locations on the Forest.

Current Condition: Current soil conditions are mostly impaired because the majority of acreage occurs on higher lying stream terraces where there is high departure from reference conditions. In general, where recreation disturbance occurs, the higher lying stream terraces have lower surface litter, understory production, poor species composition, and more visible sheet and rill erosion compared to reference conditions. These soils have reduced ability to recycle nutrients and resist erosion.

In contrast, surface litter production is higher on floodplains and there is a higher diversity and improved composition of species. Floodplains are subject to frequent flooding, and therefore have moister soils, greater vegetative productivity, and more protective vegetative ground cover to resist erosion than higher lying terraces. Overall soil productivity is low and departed on stream terraces, but is close to reference conditions on floodplains.

Desert Communities

Reference Condition: Historically, Desert Communities PNVT had mostly satisfactory soil conditions with adequate vegetative ground cover to resist erosion and ability to infiltrate water and recycle nutrients. Soil productivity overall was low, but maintained with sparse, diverse herbaceous understories and low understory and forage productivity.

Current Condition: The Desert Communities PNVT currently has about 44% impaired and unsatisfactory soil conditions, is moderately departed and static trend. Species composition at times can be poor and variable. There are few herbaceous species, including grasses, evident during dry years in areas dominated by creosote bush (a species that releases a toxin to suppress the growth of nearby plants).

Herbaceous and forage productivity is variable from year to year based on precipitation. In wet years, the interspaces between shrubs can be filled with ephemeral annual forbs and grasses, a typical desert flora. In more recent years, invasive annual grasses have been invading these interspaces. Most of these soils show evidence of compaction, reduced soil porosity and low litter cover. In creosote dominated parts of this PNVT, there are numerous gullies present. While some of the gullying is due to the highly erodible soil types in an arid system, there can be insufficient protective vegetative ground cover to prevent accelerated erosion as a result of past grazing activities and low natural vegetative ground cover in dry years.

Semi-Desert Grasslands

Reference Condition: Historically, soil condition was satisfactory, with more litter cover and higher understory and forage productivity. Soil productivity was inferred to be maintained with higher than current levels of soil litter cover, organic matter, and understory and forage productivity.

Current Condition: There are large amounts of impaired and unsatisfactory soils (high departure) in the Semi-Desert Grasslands PNVT (about 95%), resulting in reduced nutrient cycling functions (low amount of litter, low organic matter, and poor species composition) and the decreased ability of soil to infiltrate water. This is evidenced by locally compacted soils resulting in moderate departure from reference conditions. Soil productivity is moderately departed from reference conditions because it has relatively low litter and organic matter, and low understory and forage productivity.

Mixed Broadleaf Deciduous Riparian

Reference Condition: Historically, there were mostly satisfactory soil conditions, and soil productivity was inherently low but within the normal range of historic variability.

Current Condition: Currently there are mostly satisfactory soil conditions and low departure. The soils generally have high amounts of protective litter and plant cover and are not compacted. Isolated areas may be in impaired or in unsatisfactory condition. Although soil productivity is currently low on higher lying stream terraces and high along floodplains, it is functioning normally to sustain ecological systems.

Great Basin Grassland

Reference Condition: The PNVT had mostly satisfactory soil condition under reference conditions. Soil productivity was moderate to high with adequate surface litter to maintain soil productivity, and high understory and forage production. It was variable depending on terrestrial ecological unit.

Current Condition: Current soil conditions are mostly impaired and unsatisfactory (87% and high departure). Soil nutrient cycling and hydrology functions are appreciably reduced, primarily due to local weather such as drought and grazing by cattle and wildlife. From a soil productivity standpoint, understory and forage vigor and production is reduced due to herbivory, scattered trees (juniper-grassland ecotones) and drought. Surface litter is slightly reduced from reference conditions.

Interior Chaparral

Reference Condition: The soil condition in this PNVT under reference conditions is mostly inherently unstable, due to steep slopes. Chaparral communities are highly adapted to fire and have the resiliency to naturally regenerate vegetation and to protect soil productivity over time. Soil productivity for this PNVT is naturally generally low.

Current Condition: Current soil condition is similar to reference condition (<1% impaired or unsatisfactory soils, low departure). Litter cover is similar to reference conditions and sufficient to protect the soil from accelerated erosion. Soil productivity has changed little from reference conditions and is functioning normally.

Piñon Juniper Evergreen Shrub

Reference Condition: Historically, there were mostly satisfactory soil conditions. Soil productivity overall was moderate with moderate surface litter and understory and forage production.

Current Condition: Current soil conditions are mostly impaired (57% and moderate departure) due to a decline in nutrient cycling and the ability to resist erosion. Current litter and plant cover is low, and species composition is poor. Visual sheet and rill erosion are common in areas of high tree density and high canopy cover. Canopy cover greater than about 40% inhibits the growth of understory vegetation that holds the soil in place.

Currently, soil productivity is low to moderate overall with reduced surface litter and understory

Piñon Juniper with Grass

Reference Condition: Historically, the Piñon Juniper Woodland PNVT had mostly satisfactory soil conditions, and soil productivity was moderate overall with moderate surface litter and understory and forage production conditions.

Current Condition: Currently, about 28% of the PNVT has impaired and unsatisfactory soils and therefore has low departure from reference, mainly associated with areas that have greater than

about 40% canopy cover. This results in these areas having reduced nutrient cycling and increased erosion. Current litter and plant cover is low, species composition is poor, and visual sheet and rill erosion are common in areas with high tree density. Soil productivity is overall low to moderate with reduced surface litter and low forage production. The areas with low productivity are associated with unsatisfactory and impaired soils. Soil productivity has declined over time and is probably due to fire suppression and loss of understory vegetation that would have carried fire.

Piñon Juniper Woodland (Persistent)

Reference Condition: Historically, the Piñon Juniper Woodland PNVT had mostly satisfactory soil conditions, and soil productivity was moderate overall with moderate surface litter and understory and forage production conditions.

Current Condition: Currently, about 60% of the PNVT has impaired and unsatisfactory soils and therefore moderately departed. , Some areas have greater than about 40% canopy cover contributing to impaired soil functions but not as prevalent as Pinyon Juniper with Grass or Pinyon Juniper Evergreen Shrub PNVTs. Current litter and plant cover is low, species composition is poor, and visual sheet and rill erosion are common especially in areas with high tree density. Soil productivity is overall low to moderate with reduced surface litter and low forage production. The areas with low productivity are associated with unsatisfactory and impaired soils. Soil productivity has declined over time and is probably due to fire suppression and loss of understory vegetation that would have carried fire.

Similar to other PJ types, the trend under current management is probably away due to lack of PJ treatment emphasis resulting in very few acres treated over the last 15 years.

Wetland/Cienega

Reference Condition: Historically, soil condition was mostly satisfactory. In reference condition, soil productivity was high overall, with both high surface litter and understory and forage production.

Current Condition: Currently, most of the Wetland Cienega PNVT on the Forest is highly departed from reference condition. There is a high amount of unsatisfactory and impaired soils due to a combination of effects from legacy grazing that goes back to the early 1900’s, wildlife herbivory, and managed grazing to a lesser extent. Soils are commonly compacted with reduced porosity, litter, vegetative cover, and production that impair nutrient cycling functions. Soil productivity is moderate and departed from reference condition where the wetlands are unfenced. In these areas, there have been appreciable reductions in surface litter and vegetation production.

Ponderosa Pine

Reference Condition: Historically, soil conditions were satisfactory. Soil productivity was moderate with high surface litter and moderate understory and forage production.

Current Condition: Current soil conditions in most areas are similar to reference conditions. Most areas have high amounts of protective litter cover protecting the soil from accelerated erosion.

However, nutrient cycling is nearly impaired because nearly 83% of the PNVT has a closed canopy. Closed canopy areas have reduced solar radiation and abundant litter, which can prohibit germination and establishment of herbaceous vegetation that holds soil in place and carries fire. Areas with closed canopies and high densities of trees, however, do not affect the ability of the soil to produce tree biomass. Soil productivity in Ponderosa Pine is considered to have a low to near moderate departure from reference conditions. Surface organic matter and litter is currently similar to reference condition. There is a reduction in understory and forage and possibly coarse-woody material (>3" diameter), but not enough to affect long-term soil productivity.

Montane Willow Riparian Forest

Reference Condition: Historically, this PNVT had mostly satisfactory soil conditions, and soil productivity was generally maintained.

Current Condition: Montane Willow Riparian has mostly satisfactory soil condition with high amounts of litter and plant cover. Little has changed from reference conditions, and therefore, Montane Willow Riparian Forest has a low departure from reference conditions. Overall, soil productivity is functioning normally, and can maintain soil productivity levels necessary to sustain ecological systems.

Gallery Coniferous Riparian Forest

Reference Condition: Historically, this PNVT had mostly satisfactory soil conditions, and soil productivity was generally maintained.

Current Condition: This PNVT has near 100% satisfactory or satisfactory but inherently unstable soil conditions (with high amounts of litter and plant cover. Little has changed from reference conditions, and therefore, has a low departure from reference conditions. Overall, soil productivity is functioning normally, and can maintain soil productivity levels necessary to sustain ecological systems.

Montane Subalpine Grassland

Reference Condition: This PNVT had mostly satisfactory soil conditions, and soil productivity was generally maintained.

Current Condition: Montane grasslands (areas lower than about 7,200 feet, (all Montane Subalpine Grassland TES map units except 640) currently have relatively large amounts of impaired soils. These soils have low vegetative ground cover, poor species composition and productivity, and show signs of extensive compaction and reduced ability to infiltrate water. Subalpine grasslands (areas higher than 7,200 feet and only TES map unit 640) have more extensive vegetative ground cover, good species composition and plant productivity, and porous soils and are in satisfactory soil condition.

Mixed Conifer Frequent Fire

Reference Condition: Historically, the Dry Mixed Conifer PNVT had mostly satisfactory soil conditions, and soil productivity was functioning within reference conditions.

Current Condition: Soil condition and productivity are similar to reference conditions and has low departure. Overall, there are high amounts of protective litter to prevent accelerated erosion. Soil productivity is functioning normally and can maintain levels necessary to sustain ecological systems.

Mixed Conifer with Aspen

Reference Condition: Historically, this PNVT had mostly satisfactory soil conditions, and soil productivity was functioning within reference conditions.

Current Condition: Soil condition and productivity are similar to reference conditions with low departure. Overall, there are high amounts of protective litter to prevent accelerated erosion. Soil productivity is functioning normally and can maintain levels necessary to sustain ecological systems.

Spruce Fir

Reference Condition: Historically, the Spruce Fir PNVT had mostly satisfactory soil conditions, and soil productivity was functioning within the HRV.

Current Condition: Soil condition and productivity are similar to reference conditions (low departure). Overall, there are high amounts of protective litter to prevent accelerated erosion. Soil productivity is functioning normally and can maintain levels necessary to sustain ecological systems.

Alpine Tundra

Reference Condition: The soil condition for Alpine Tundra is mostly inherently unstable. Soil productivity was normally generally low, functioning normally, and maintaining levels necessary to sustain ecological systems.

Current Condition: The soil condition for Alpine Tundra remains mostly inherently unstable (low departure). These soils have high amounts of rock cover and normal amounts of vegetative ground cover to prevent accelerated erosion. Soil productivity also has changed little from reference conditions. Soil productivity remains normally generally low, functioning normally, and maintaining levels necessary to sustain ecological systems.

Soil Crusts

Mosses and other crust forming organisms are found in wetter environments, but are less important to overall soil productivity. An important component that affects soil condition is the condition of soil crusts. Microbiotic crusts are the community of organisms, including cyanobacteria,[2] green algae, microfungi, mosses, liverworts and lichens, living at the surface of soils (USDI GS 2006). Biological soil crusts are commonly found in Piñon Juniper Woodland, Semi-Desert Grassland, and Desert Communities on the forest and to a limited extent in other vegetation types dryer than Piñon Juniper Woodland. Of most importance is the role crusts play in maintaining productivity of the Semi-Desert Grassland and Great Basin Grassland and pinyon juniper woodland ecosystems.

Crusts are well adapted to severe growing conditions, but poorly adapted to compressional disturbances. Domestic livestock and elk grazing, and more recently, recreational activities (hiking, biking, and off-road driving) place a heavy toll on the integrity of the crusts. Disruption of the crusts brings decreased organism diversity, soil nutrients, stability (and increased soil loss), and decreased organic matter and soil productivity. Studies of trampling disturbance have noted that losses of moss cover, lichen cover, and cyanobacterial presence can be severe, runoff can increase by half, and the rate of soil loss can increase six times without apparent damage to vegetation (Belnap, et. al. 2001). Ungulate grazing in PNVTs where crusts are present, poses an unquantifiable risk to soil productivity and ecosystem diversity and those species that depend on its habitat for their survival.

According to Belnap, et.al. (2001), biological crusts are generally killed by hot ground fires, resulting in loss of biomass and visible cover. Damage and recovery of biological crusts depends on pre-fire conditions as well as characteristics of the fire. Historic burning left small patches of unburned areas between bunchgrasses or at larger scales, left patches of unburned shrubs across the landscape. Historic fires in these areas were also relatively infrequent which allowed for late successional stages of biological crusts.

Most areas where crusts have been observed currently cover less than 5 percent of the soil surface and are most prevalent in coase-textured soils especially in pinyon-juniper and Semi-Desert Grassland PNVTs (Steinke, personal observations, 1989-2011)

[2] Cyanobacteria include a number of species of bacteria that obtains their energy through photosynthesis.

Environmental Consequences

The forest use soil condition as a descriptive indicator of general soil health. In this analysis, the expected trends in soil condition are described for each alternative for comparison. The general effects to soil function of common management activities follow, such as: forest restoration activities (mechanical and burning treatments), roads, recreation, grazing, and special uses.

The environmental consequences of implementing plan direction are analyzed both forest-wide and by PNVT by alternative. Overall, and for most PNVTs implementing direction in Alternatives B, C, and D would move or improve soil condition and productivity and at a rate faster than Alternative A. Table 2 and 3 details estimated trends toward identified desired conditions by PNVT.

Table 4 summarizes major treatment objectives amongst alternatives.

Soil Condition and Productivity Trends

Table 3 displays the projected trends in soil condition and productivity based on predicted changes in soil condition including change in vegetative ground cover, soil loss and soil structure. Each vegetation type was examined to see whether soil conditions would generally trend toward, away or remain static with the implementation of plan components including desired conditions, guidelines, and objectives of each alternative.

Generally, alternative A's trend is variable ranging from slowly towards to away from desired condition and at variable rates. Alternatives B, C, and D would remain static or move toward their identified desired conditions at faster rates depending on PNVT. Plan language in alternative A states maintain or enhance soil productivity. The goal to maintain or enhance soil productivity is similar to the proposed action desired condition where soil condition and productivity is sustained. However, plan language in alternatives B, C, and D provide additional and more site-specific direction that favors maintenance and improvement of soil condition and productivity.

Alternative C is similar to B and D, except it recommends 13 new wilderness areas, 8 additional management areas for wildlife habitat, restricts grazing in RNAs, designates some areas as not suitable for recreational shooting and designates some management areas as semi-primitive non-motorized. Compared to alternatives B and D, implementing direction in alternative C plan direction would probably result in similar improvement in soil condition and productivity. Few roads and motorized trails are present under current conditions and so the improvement to soil would be small. Also, grazing would continue in the recommended wilderness areas under alternative C, so there would be no improvement to soils from changes in grazing. Therefore, predicted soil improvement would be similar to alternatives B and D.

Under alternative D, mechanized recreation on designated trails in botanical and geological areas could add to loss of soil productivity and contribute to sediment into connected stream courses and degrade water quality but would be very minor in extent. There are very few acres of riparian areas present and trails would not be designated within streamside management zones so changes in soil condition and productivity would be similar to alternatives B and C.

There are no measurable differences among alternatives B, C, and D in plan components or anticipated outcomes for soil improvement. The primary differences between alternative A versus B, C, and D are added emphasis on managing or treating specific PNVTs, increases in upland soil and watershed improvement projects, and in road naturalization and decommissioning. This would improve soil condition and long-term soil productivity faster in alternatives B, C, and D than in alternative A.

Table 3. Estimated trends in soil condition/productivity for each PNVT by alternative.

PNVT	Current Departure From Desired Conditions*	Trend Relative to Desired Conditions			
		Alt. A**	Alt. B	Alt. C	Alt. D
Cottonwood Willow Riparian Forest	High	Slowly toward			
Mixed Broadleaf Deciduous Riparian Forest	Low	Static	Slowly toward		
Montane Willow Riparian Forest	Low	Static	Slowly toward	Slowly	Slowly toward
Gallery Coniferous Riparian Forest	Low	Static			
Desert Communities	Moderate	Static	Slowly toward		
Semi-Desert Grassland	High	Slowly toward	Toward		
Great Basin Grassland	High	Slowly toward	Toward	Toward	Toward
Montane/ Subalpine Grassland	Overall High (High for Montane, Low for Subalpine)	Static	Toward	Toward	Toward
Interior Chaparral	Low	Static	Toward		
Piñon Juniper with Grass	Low	Away	Slowly toward	Slowly toward	Slowly toward
Piñon Juniper Evergreen Shrub	Moderate	Away	Slowly toward		
Piñon Juniper Woodland (Persistent)	Moderate	Away	Slowly toward	Slowly toward	Slowly toward
Ponderosa Pine	Low	Static	Toward		
Mixed Conifer(Frequent Fire)	Low	Static	Slowly toward		
Mixed Conifer with Aspen	Low	Static	Slowly toward		
Spruce-Fir	Low	Static			
Alpine Tundra	Low	Static			
Wetland/Cienega	High	Static	Toward	Toward	Toward

PNVT	Current Departure From Desired Conditions*	Trend Relative to Desired Conditions			
		Alt. A**	Alt. B	Alt. C	Alt. D

*Current departure estimates (USDA Forest Service 2009 and 2009a). Desired conditions are equivalent to reference conditions.

**Alternative A is based on the past 10-year average of treatments. Alternatives B, C, and D are based on midpoint of the objective level of treatments.

For details of individual soil condition classes and percentages, see analysis by PNVT and soil specialist report, (USDA, 2013) and ESR, (USDA 2009) and USDA 2009. Some data in the cited reports are outdated. Additional analysis, including the new PNVTs, are included in this report and supersedes the other reports cited.

Forest-wide Plan Language

Alternatives are compared based on their ability to move the soil resource towards these plan components (Desired Condition, Guidelines and Objectives):

- Alternative A: Description of **Goal, Desired Conditions and Objectives:**
  Maintain or enhance soil productivity. Put all areas in satisfactory condition by 2020.

  Alternatives B, C, D: Description of desired conditions (outcomes) and guidelines:

  Soil productivity and function is sustained and functions normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover is maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion minimized due to plant diversity. Objectives are listed in table 4.

  Comparison to Alts B, C, and D:

  The goal to maintain or enhance soil productivity is similar to the proposed revised plan and some of Alternatives B, C, and D desired conditions where soil condition and productivity is sustained. Both directions are essential to soil productivity and attainable due to the generality of the statements.

  Plan direction for all alternatives have similar plan components desired conditions for soil productivity and condition except desired conditions and guidelines under alternatives B, C, and D include more emphasis on protecting soil productivity and function though natural and human disturbances . There is additional and more soil and PNVT specific plan language under Alternatives B, C, and D including desired outcomes that would better sustain soil function compared to alternative A. Alternatives B, C and D desired conditions would require management from human disturbances and allow natural disturbances to result in sufficient organic ground cover and native herbaceous vegetation that protects soil from accelerated erosion and compaction, and contributes to ecosystem diversity sufficient to maintain desired tree density, coarse woody debris and soil nutrient cycling. Managing ground cover and tree density to meet these desired outcomes would improve soil condition trend in this PNVT whereas alternative A would remain static.

  Alternative A: The objective of attaining all areas forest-wide in satisfactory condition is unrealistic and unattainable under current budget authority. Since about 27% of forest or nearly 500,000 acres are still not in satisfactory condition. Current rate of implementation for soil protection, maintenance and improvement over last 10 years is about 20,000 acres/yr regardless of soil condition class. Even if all treatments were focused on soils not in satisfactory condition,at this rate, it would take about 25 years to improve all to satisfactory condition and plan life is about 15 years.

  Comparison to alternatives B, C, and D: These alternatives have an attainable objective that addresses implementation of soil resource maintenance and improvement projects at a rate of 100,000-350,000 acres/10 years. This would treat between 5-20% of all soils requiring maintenance or improvement and if targeting only impaired or unsatisfactory

soils, could treat between 20-70% on the forest if focusing on impaired and unsatisfactory soils only resulting in moving towards desired conditions listed above in alternatives B, C, and D faster than alternative A.

Alternative A:

The current plan does not have focused direction to emphasize treatment of impaired and unsatisfactory soil conditions whereas plan language for Alts B, C, and D, does.

Comparison to alternatives B, C, and D: These alternatives have objectives directing treating impaired and unsatisfactory soils such that they are trending towards satisfactory soil conditions both within and out of high priority watersheds. Implementing plan language for Alts B, C and D could focus treatments directly on those soils with the greatest need for change resulting in greater improvement of soil condition compared to alternative A.

- Alternative A:
  No written direction to maintain satisfactory soils in satisfactory condition

  Comparison to Alts B, C, and D:

  The current plan does not have focused direction to emphasize treatment of satisfactory soil conditions whereas plan language for alternatives B, C, and D does. Alts B, C, and D include direction to maintain satisfactory soils in satisfactory condition so that soil degradation and loss of soil productivity won't occur. Alternative A does not and risks allowing satisfactory soils to degrade and lose soil productivity over the long-term more than B, C and D.

- Alternative A:
  No plan direction to improve soil conditions on a PNVT basis. Table 4 compares and details the differences.

  Comparison to Alts B, C, and D:
- The current plan does not have focused direction to improve soil conditions and emphasize treatments on a PNVT basis whereas plan language for Alts B, C, and D, does. Alternatives B, C, and D include direction to focus treatments on PNVTs with the greatest need for change in soil condition and productivity Table 4 compares and details the differences. Implementation of plan language under Alts B, C, and D would result in greater soil improvement for PNVTs where needed compared to Alt. A.

- Alternative A:
  Missing direction to implement watershed restoration on a 5th or 6th HUC watershed basis including development of watershed action plans. .

  Comparison to Alts B, C, and D:

  The current plan does not have focused direction to implement watershed restoration on a 5th or 6th HUC basis whereas plan language for alternatives B, C, and D does. Alternatives B, C, and D include development of watershed action plans on priority watershed with the greatest need for change in soil condition and productivity. Implementing plan language for alternatives B, C and D would focus treatments on

priority watersheds identified as having the greatest need for change of soil, riparian and water conditions resulting in greater improvement of watershed conditions compared to alternative A.

- Alternative A:
  Lack of direction for soil crust maintenance

  Comparison to alternatives B, C, and D:

  Description of desired condition and guideline for soil crusts. Biological soil crusts are present and functioning on coarse textured soils. Guideline: Minimize disturbance in areas where crusts exceed 5%. The current plan does not recognize the importance of protecting soil crusts to maintain soil productivity. Implementing plan direction for Alts B, C, and D would better protect biological soils crust and improve soil nutrient cycling compared to Alt. A.

- Plan component direction for emergency fire assessment and rehabilitation are now contained in FSM direction. Current and revised plans due not conflict but compliment BAER FSM direction.

- Plan component direction for use of TES in planning is now contained in FSM direction.

- Plan directs additional on-site soil investigations for soil disturbing projects requiring more detailed soil information. This direction is still appropriate and carried through to the proposed plan.

- Implement and monitor BMP's already appropriately exists in Alternative A and similarly is contained under Alternatives B, C, and D. 1987 plan direction is appropriate and carried forward to this plan.

Table 4. Soil Objectives by PNVT and Alternative

Treatment Type	Alternative A	Alternative B	Alternative C	Alternative D
Soil resource improvement projects including hazardous fuel reduction (for all PNVTs)	Goal: Maintain or enhance soil productivity. Objective: All soils to be in satisfactory condition by 2020. On an Opportunity Basis. Averaged 20,000 acres/yr or about 11% of all soils.	Desired Condition: Soil condition and productivity is sustained. Objective: 100,000-350,000 acres per 10 years or 5-20% of all soils Or 20-70% of impaired or unsatisfactory soils in 10 years when targeting impaired and unsatisfactory soils.	Same as B	Same as B
Restoration of Priority (Focus watersheds)	0	5-7/10 years or between 5-7% of Forest	Same as B	Same as B
Riparian Treatment Objectives across all riparian vegetation types	80% of riparian areas are recovered by 2030 Acres implemented is < 175 or 3% of total	200 – 500 Acres Would treat about twice as many acres as Alternative A or 10% of total	Same as B	Same as B
Road Removal Objectives including from riparian areas	400 miles in 10 years.	200-800 road miles naturalized or decommissioned	Same as B	Same as B
Wetland/Cienega Objective	Opportunity Basis	Restore 5 to 10 wetlands in 10 years or 15-30% of total	Same as B	Same as B

Treatment Type	Alternative A	Alternative B	Alternative C	Alternative D
Ponderosa Pine Mechanical Harvesting/Thinning/Under burning	Variable but much less in last 15 years	50,000-260,050 acres/10 years	Same as B	Same as B
Pinyon-Juniper Grasslands Vegetation Treatments	Opportunity Basis	1000-10,000 acres/10 years	Same as B	Same as B
Semi Desert Grassland PNVT Thinning/Burning	Opportunity Basis	3500 acres/10 years	Same as B	Same as B
Great Basin Grassland PNVT Thinning/Burning	Opportunity Basis	7600-11,400 acres/10 years	Same as B	Same as B
Prescribed Fire	Opportunity average is about 160,000 acres for Ponderosa Pine and 5370 for Mixed Conifer	150,000-300,000 acres/10 years (Ponderosa Pine) 8000 acres Mixed Conifer(frequent fire)	Same as B	Same as B
Wildfires (Resource Benefit Fires)	Opportunity average is 86,200 for Ponderosa Pine	135,000 acres/10 years (Ponderosa Pine) 3,750/10 yrs (for each: PJ with grass and PJ-evergreen shrub)	Same as B	Same as B
Mixed Conifer with Frequent Fire		7500 acres/10 years of resource benefit fire (frequent fire) and up to 8000 acres/10 yrs low severity fire		

Alternative A is based on the last 10 year average and ranged from about 12,000 – 28,000 acres/yr. However, alternative A mechanical thinning and prescribed burning treatments did not specifically target impaired and unsatisfactory soil condition. Other watershed treatments listed targeted improvement of impaired and unsatisfactory soil conditions.

Treatments

Mechanical Treatments

Table 1. Projected Acres of Mechanical Cutting Treatments by PNVT and Alternative. Many of these treatments require burning piled slash as well as using low severity broadcast burning to remove scattered fuels. Values are for 10 years.

Treatment	Thinning (Group Selection or Free Thinning
Severity-Low	Range or Total
Alt. A PPF	TBD
PPF Alt. B, C, D	50,000-260,050
DMC Alt. A	0
DMCF Alt. B, C, D	0
PJG Alt. B, C, D	1000-10,000
PJES Alt. A, B, C, D	0
PJW- Persistent A-D	0
All Types Alt. A	TBD
All Types Alt. B, C, D	51,000-270,050

Alternative A is based on 25 year average.

Many of these treatments include both mechanical cutting treatments followed by low severity broadcast burning mentioned above. Other watershed treatments include pinyon-juniper lop and scatter, montane meadow restoration, shrub eradication, decommissioning of roads, removal and restoration of dispersed campsites and stream channel restoration. Values are for 10 years.

Burning Treatments

With respect to fire, alternative A would result in a trend toward less acreage treated and higher fire intensities, mainly due to constraints on unplanned wildfires to meet resource objectives and a lack of emphasis on fire restoration.

Prescribed fires and wildfires used to meet resource objectives also may also affect soil's physical, chemical, and biological characteristics negatively. The most important soil physical characteristic that affects soil hydrologic function and soil stability is soil structure, because the organic matter component, which provides for loose, granular structure, can be lost at relatively low temperatures. The loss of soil structure increases the bulk density of the soil and reduces its porosity, thereby reducing soil productivity and making the soil more vulnerable to post-fire runoff and erosion.

<u>Prescribed Fire</u>

Use of prescribed fire allows the manager the opportunity to control the severity of the fire and to avoid creating large areas burned at high severity. Each alternative proposes the use of prescribed fire for fuel reduction and ecosystem restoration. Alternative B, C, and D prescribes more than

Alternative. Fire treatments are designed to kill overstory vegetation to reduce the amount of canopy cover to a desired level.

Under all alternatives, prescribed fire is allowed to burn under strict conditions and prescriptions that should not result in large areas of high burn severity that would be detrimental to soil physical, chemical, or biological properties resulting in loss of soil productivity.

Alternative A allows use of prescribed and managed fires but contains no objectives and occurs on an opportunity basis.

Alternatives B, C, and D contain objectives for PNVTs that are fire adapted directing an ambitious fire program that should maintain and improve soil condition and productivity over the long-tern better than Alterative A.

Roads: Existing and New Construction

New road construction is generally not required for timber harvesting or fuel reduction within the planning area, however, the re-opening of level 1 (those roads placed in storage between intermittent uses) dramatically increases the amount of open roads and, potentially, the amount of soil erosion that occurs during the life of a project. Occasionally, temporary road construction would also remove vegetation along the road corridor, expose mineral soil, and result in soil compaction along the roadbed. Typically, there is pulse of erosion from roads during the first two years following road construction or reopening (MacDonald and Coe 2008; Megahan 1974). Slope failures and mass movement of soils may occur as the result of road construction. New roads or re-opening closed roads may also provide an avenue for the invasion and establishment of invasive plant species. New temporary roads would be closed, obliterated, and revegetated following use. Road design, avoidance of problem soils, appropriate design criteria, and road closures would be implemented in order to minimize impacts to soils.

The road system (miles, management level, and location) is the same for all alternatives, however, use of roads and the additional amount of level 1 roads are estimated to be higher in alternative B, C, and D because they would have the greatest percentage of timber harvest/mechanical restoration treatments of all alternatives. Many of these level 1roads would only be used during project implementation and closed immediately after. These roads would revegetate naturally and not result in major contributions of erosion and sediment delivery into streamcourses in the long term.

Alternatives B, C and D have objectives to naturalize or decommission 200-800 miles within a 10 year time frame while Alterative A has an objective to treat 400 in 10 years. Therefore, implementation of Alts B, C and D plan direction could result in naturalization or decommissioning up to twice as many road miles as A or twice as less on the low range. Implementing the upper range (800 miles/10 years) would result in a reduced road network and reduced potential of roads to contribute to road bed and cut and fill slope erosion , and sediment delivery to connected streamcourses and improved water quality downstream. Conversely, implementing direction at the low end of the range (200 miles/10 years) would result in a greater road network than in A and increased potential of roads to contribute to road bed and cut and fill slope erosion , and sediment delivery to connected streamcourses and improved water quality downstream.

Recreation Activities

Recreational uses shown to impact soils include off-road motor vehicle use, camping, hiking, mountain biking, and horseback riding. All of these activities may result in erosion and compaction. These impacts tend to be minor, and may occur on only a small percentage of the planning area.

Plan language under all Alternatives directs implementing site specific BMPs and SWCPs for recreation projects would minimize adverse soil impacts. The impacts from recreation could occur about the same under all of the alternatives.

Grazing Activities

Improper grazing management has the potential to reduce soil condition directly through hoof compaction, and indirectly from the removal or protective vegetation and subsequently, ground cover. The effects to soil condition are reduced soil hydrologic function in highly compacted cattle concentration areas, and reduce soil stability from loss of ground cover wherever over utilization of available forage exists. Grazing is not considered detrimental where sufficient herbaceous material remains to protect the soils during periods of intense summer rains, or during spring runoff.

Differences in soil condition as related to grazing impacts between alternatives are indirectly tied to the level of restoration treatments provided for each alternative. Overstory canopy cover prescribed in the desired conditions provides the potential for an increase in understory vegetation as treatments are implemented and maintained. The relationship between overstory cover and herbaceous production has been validated in Arizona forests (Jameson, et.al. 1967; Thill, et.al. 1983). This increase would indirectly reduce grazing pressure as treatments progress across the forest. Increases in available forage would allow range managers flexibility in management to favor rehabilitation or rest in areas that are currently not in satisfactory soil condition, such as found in riparian, grassland and woodland vegetation.

Plan language under all Alternatives directs implementing site specific BMPs and Soil and Water Conservation Practices provide protection from the effects of grazing and are prescribed in project-level analysis.

Special Uses

Terms and conditions of special use permits would require site specific BMPs to provide for maintenance of soil productivity in all alternatives. Therefore, there are no anticipated effects to soil condition from permitted special use activities.

Plan language under all Alternatives directs implementing site specific BMPs for ground disturbing projects. The soil and water quality impacts from disturbances associated under a special use permit would be similar under all of the alternatives.

Soil Crusts

Crusts are affected directly through physical damage and alteration of habitat. Compressional forces compact the soils hydrologic function, which could provide less water and nutrients to biological crusts. Across all alternatives, it is estimated that on-going improved cattle management on the forests would benefit biological crusts. Reduction in grazing pressure due to estimated increases in forage production would benefit crusts as well. Fire also kills biological crusts and can alter soil properties as well. Individual ground disturbing projects including burning would require site specific analysis to mitigate effects to biological crust, especially in the woodland and grassland vegetation types.

The current plan (Alternative A) does not recognize the importance of protecting soil crusts to maintain soil productivity while Alternatives B, C and D provide a description of desired conditions for soil crusts. Biological soil crusts are present and functioning on coarse textured soils. Implementing this direction should result in better protection of soil crusts necessary to maintain soil productivity compared to Alternative A.

Wilderness Areas, RNA's and Management Areas

Alternative C:

Alternative C is similar to B and D, except it recommends 13 new wilderness areas, 8 additional management areas for wildlife habitat, restricts grazing in RNAs, designates some areas as not suitable for recreational shooting and designates some management areas as semi-primitive non-motorized. Compared to alternatives B and D, implementing direction in alternative C plan direction would probably result in similar improvement in soil condition and productivity. Therefore, predicted soil improvement would be similar to alternatives B and D.

There are no measurable differences among alternatives B, C, and D in plan components or anticipated outcomes for soil improvement. The primary differences between alternative A versus B, C, and D are added emphasis on managing or treating specific PNVTs and increases in upland soil and watershed improvement projects, and in road naturalization and decommissioning. This would improve soil condition and long-term soil productivity faster in alternatives B, C, and D than in alternative A.

Alternative D:

Under Alternative D, mechanized recreation on designated trails in botanical and geologic areas could add to loss of soil productivity and contribute to sediment into connected streamcourses and degrade water quality but would be very minor in extent. There are very few acres of riparian areas present and trails would not be designated within streamside management zones so changes in soil condition and productivity would be similar to Alternatives B and C.

There are no measurable differences among alternatives B, C, and D in plan components or anticipated outcomes for soil improvement. The primary differences between alternative A versus

B, C, and D are added emphasis on managing or treating specific PNVTs and increases in upland soil and watershed improvement projects, and in road naturalization and decommissioning. This would improve soil condition and long-term soil productivity faster in alternatives B, C, and D than in alternative A.

PNVTs

Comparison of Forest-wide Plan Language in Alternatives A, B, C, D

Plan direction for all alternatives have similar plan components desired conditions for soil productivity and condition except desired conditions and guidelines under Alts B, C, and D include more emphasis on protecting soil productivity and function though natural and human disturbances . There is additional and more soil and PNVT specific plan language under Alternatives B, C, and D including desired outcomes that would better sustain soil function compared to Alternative A. Alternatives, B, C and D desired conditions would require management from human disturbances and allow natural disturbances to result in sufficient organic ground cover and native herbaceous vegetation that protects soil from accelerated erosion and compaction, and contributes to ecosystem diversity sufficient to maintain desired tree density, coarse woody debris and soil nutrient cycling. Managing ground cover and tree density to meet these desired outcomes would improve soil condition trend in this PNVT whereas Alternative A would remain static.

Common to All Riparian Forest Types and Wetland/Cienega

Riparian direction under alternative A is lacking or vague and does not provide clear direction to maintain or restore riparian areas toward maintaining or improving soil condition toward satisfactory condition or sustaining soil function where the soil has the ability to resist erosion, infiltrate water and recycle nutrients. The current rate of implementation for soil improvement is low and centered largely on improving grazing strategies. Without specific plan emphasis and objectives targeting this PNVT, soil improvement (soil condition and productivity) for the remaining areas not in satisfactory condition under alternative A would be limited and would probably remain the same or static as it relates to movement toward desired conditions.

Cottonwood Willow PNVT

An environmental consequences analysis of riparian function comparing implementation of forest plan components by alternative can be found in the (USDA Forest Service 2013).

The following analysis compares implementing plan components by alternative as it relates to soil condition and productivity.

Alternative A.

Comparison of current, reference and projected future conditions: There is a high departure in soil condition (98%) and soil productivity because most of the acreage that is departed occurs on stream terraces where most recreation use occurs. Current management is resulting in

improvements and a slow trend towards reference conditions in most locations. There are localized areas where the trend is away from satisfactory conditions due to high recreation use or where improved cattle grazing strategies have not yet been implemented.

Under current management direction (including improved grazing strategies), overall soil condition and productivity would trend slowly towards reference conditions in most areas. The goal of attaining all areas in satisfactory condition by 2020 would be very difficult to attain under current budget authority unless heavy emphasis and project funding would target this PNVT. Current rate of implementation for soil improvement in this PNVT is unknown but estimated to be low, on an opportunity basis and would take decades to bring all soils into satisfactory condition.

Under current plan direction (alternative A) , litter, vegetation composition, and understory productivity are expected to slowly improve. In some areas, however, both soil condition and productivity are trending away from reference conditions where improved grazing strategies have not yet been implemented, as well as in high recreation impacted areas such as Fossil Creek and other major tributaries to the Verde River.

Alternative A, B, C, and D

The current plan forest-wide goal, desired condition and objectives to maintain or enhance soil productivity attaining all areas in satisfactory condition by 2020 would be very difficult to attain under current budget authority. Current rate of implementation for soil improvement in this PNVT is low and centered largely on improving grazing strategy and not mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement (soil condition and productivity) under alternative A would be very limited, on an opportunity basis and would slowly move towards identified desired conditions listed under alternatives B, C, and D.

Management of riparian areas would continue in accordance with direction in the 1987 Forest Plan (as amended). Riparian direction is lacking or vague and does not provide clear direction to maintain or restore riparian areas toward revised plan (Alts B, C, and D) desired conditions and objectives of maintaining or improving soil condition towards satisfactory condition or sustaining soil function where the soil has the ability to resist erosion, infiltrate water and recycle nutrients. Over the last 10 years, only a few riparian areas have been improved and most due to improved grazing strategies implemented.

Alternative B, C, and D treatments would include plan components that would move riparian areas towards identified desired conditions. In addition, a guideline directing identification of a vegetated streamside management zone, maintenance of 80% herbaceous cover and limited and localized soil compaction and trampling of vegetation should be to the extent where permanent damage to perennial plant would not occur resulting in maintenance of soil cover, reduced sheet erosion, and improved nutrient cycling and soil productivity. The forest-wide objective of restoration of 200-500 acres of any non-functional or functional at risk riparian PNVT within 10 years would treat and improve about twice as many acres as estimated in Alterative A or 10% of total riparian areas forest wide and proportionally more per plan life of 15 years.

Implementation of plan components under Alternatives B, C, and D, would indirectly cause the following scenario to occur. Riparian vegetation would improve aiding in the ability to filter sediments, improve soil structure, improve nutrient cycling, improve water retention and ground

water recharge and develop root masses that stabilize against cutting action associated with high water flow, thereby reducing erosion, improving water quality and maintaining soil productivity.

Continuing implementation of Alternative A would probably not maintain or improve soil condition or productivity or move a large number of riparian areas to identified desired conditions as quickly as Alternatives B, C, and D. Although implementing plan direction under Alternatives B, C, and D would move soils to desired conditions faster than Alternative A, movement towards desired conditions would probably still be slow based on overall small numbers of acres plan component objectives propose.

Mixed Broadleaf Deciduous Riparian PNVT

An environmental consequences analysis of riparian function comparing implementation of forest plan components by alternative can be found in the Riparian Specialist Report, Steinke, 2011).

The following analysis compares implementing plan components by alternative as it relates to soil condition and productivity.

Alternative A

Comparison of current, reference and projected future conditions: Under current management and plan direction, the departure from reference conditions is low, soil mostly satisfactory (about 94%) and the projected trend is static for soil condition and productivity.

Most of this PNVT is located in areas with no motorized or livestock access and, therefore, has limited soil disturbance. Under current plan direction, this is not projected to change. Litter, vegetation composition, and understory productivity are expected to remain about the same or improve in impaired or unsatisfactory soils that are minor in extent. The goal of attaining all areas in satisfactory condition has for the most part, already been attained.

The current plan forest-wide goal of attaining all areas in satisfactory condition may be possible since about 94% of this PNVT is already in satisfactory condition. However, current rate of implementation for soil improvement in this PNVT is low and centered largely on improving grazing strategy and not mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement (soil condition and productivity) for the remaining areas not in satisfactory condition under Alternative A would be limited, on an opportunity basis and would probably remain the same or static as it relates to movement towards identified desired conditions.

Under the current plan, management of riparian areas would continue in accordance with direction in the 1987 Forest Plan (as amended). Riparian direction is lacking or vague and does not provide clear direction to maintain or restore riparian areas toward revised plan (Alts B, C, and D) desired conditions and objectives of maintaining or improving soil condition towards satisfactory condition or sustaining soil function where the soil has the ability to resist erosion, infiltrate water and recycle nutrients. Over the last 10 years, only a few riparian areas have been improved and most due to improved grazing strategies implemented.

Alternatives B, C, and D

Alternative B, C, and D treatments would include plan components that would move riparian areas towards identified desired conditions. The soils would have high amounts of protective litter and plant cover and soils would not be compacted. In addition, a guideline directing identification of a vegetated streamside management zone, maintenance of 80% herbaceous cover and limited and localized soil compaction and trampling of vegetation should be to the extent where permanent damage to perennial plant would not occur resulting in maintenance of soil cover, reduced sheet erosion, and improved nutrient cycling and soil productivity. The forest-wide objective of restoration of 200-500 acres of any non-functional or functional at risk riparian PNVT within 10 years would treat and improve about twice as many acres as estimated in Alterative A or 10% of total riparian areas forest wide and proportionally more per plan life of 15 years.

Implementation of plan components under Alternatives B, C, and D, would indirectly cause the following scenario to occur. Riparian vegetation would improve aiding in the ability to filter sediments, improve soil structure, improve nutrient cycling, improve water retention and ground water recharge and develop root masses that stabilize against cutting action associated with high water flow, thereby reducing erosion, improving water quality and maintaining soil productivity.

Continuing implementation of Alternative A would probably not maintain or improve soil condition or productivity or move a large number of riparian areas to identified desired conditions as quickly as Alternatives B, C, and D. Although implementing plan direction under Alternatives B, C, and D would move soils to desired conditions faster than Alternative A, movement towards desired conditions would probably still be slow based on overall small numbers of acres plan component objectives propose.

Montane Willow Riparian PNVT

An environmental consequences analysis of riparian function comparing implementation of forest plan components by alternative can be found in the Riparian Specialist Report, Steinke, 2011).

The following analysis compares implementing plan components by alternative as it relates to soil condition and productivity.

Alternative A.

Comparison of current, reference and projected future conditions: Under current management and plan direction, soil condition is mostly satisfactory (about 93%) and soil productivity is similar to reference condition. There are some areas in the Upper Clear Creek 5th code HUC that probably have higher amounts of unsatisfactory soil conditions than the data suggests (personal observations). Projected trends are static for both soil condition and soil productivity.

Under current management, both soil condition and productivity are projected to remain static in the future. Litter, vegetation composition, and understory productivity are expected to remain about the same or improve in impaired or unsatisfactory soils that are minor in extent. The goal of attaining all areas in satisfactory condition has for the most part, already been attained.

Alternative A

The current plan forest-wide goal of attaining all areas in satisfactory condition may be possible since about 93% of this PNVT is already in satisfactory condition. However, current rate of implementation for soil improvement in this PNVT is low and centered largely on improving grazing strategy and not mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement (soil condition and productivity) for the remaining areas not in satisfactory condition under Alternative A would be limited, on an opportunity basis and would probably remain the same or static as it relates to movement towards identified desired conditions.

Under the current plan, management of riparian areas would continue in accordance with direction in the 1987 Forest Plan (as amended). Riparian direction is lacking or vague and does not provide clear direction to maintain or restore riparian areas toward revised plan (Alts B, C, and D) desired conditions and objectives of maintaining or improving soil condition towards satisfactory condition or sustaining soil function where the soil has the ability to resist erosion, infiltrate water and recycle nutrients. Over the last 25 years, a few riparian areas have been improved and most due to improved grazing strategies implemented.

Alternatives B, C, and D

Alternative B, C, and D treatments would include plan components that would move riparian areas towards identified desired conditions. These soils would have high amounts of protective litter and plant cover along with spongy, not compacted soils. In addition, a guideline directing identification of a vegetated streamside management zone, maintenance of 80% herbaceous cover and limited and localized soil compaction and trampling of vegetation should be to the extent where permanent damage to perennial plant would not occur resulting in maintenance of soil cover, reduced sheet erosion, and improved nutrient cycling and soil productivity. The forest-wide objective of restoration of 200-500 acres of any non-functional or functional at risk riparian PNVT within 10 years would treat and improve about twice as many acres as estimated in Alterative A or 10% of total riparian areas forest wide and proportionally more per plan life of 15 years.

Implementation of plan components under Alternatives B, C, and D, would indirectly cause the following scenario to occur. Riparian vegetation would improve aiding in the ability to filter sediments, improve soil structure, improve nutrient cycling, improve water retention and ground water recharge and develop root masses that stabilize against cutting action associated with high water flow, thereby reducing erosion, improving water quality and maintaining soil productivity.

Continuing implementation of Alternative A would probably not maintain or improve soil condition or productivity or move a large number of riparian areas to identified desired conditions as quickly as Alternatives B, C, and D. Although implementing plan direction under alternatives B, C, and D would move soils to desired conditions faster than alternative A, movement toward desired conditions would probably still be slow based on overall small numbers of acres identified for restoration in plan objectives.

Gallery Coniferous Riparian PNVT

An environmental consequences analysis of riparian function comparing implementation of forest plan components by alternative can be found in the Riparian Specialist Report, (USDA, 2013).

Alternative A.

Comparison of current and reference condition: Under current management and plan direction, soil condition is almost all satisfactory and soil productivity is similar to reference condition. Little has changed from reference conditions, and therefore, has a low departure from reference conditions. Overall, soil productivity is functioning normally, and can maintain soil productivity levels necessary to sustain ecological systems.

Under current management, both soil condition and productivity are projected to remain static in the future. Litter, vegetation composition, and understory productivity are expected to remain about the same. The goal of attaining all areas in satisfactory condition has for the most part, already been attained.

Alternatives A, B, C, and D

The current plan forest-wide goal of attaining all areas in satisfactory condition may be possible since about 99% of this PNVT is believed to be in satisfactory condition. Current rate of implementation for soil improvement in this PNVT is centered largely on improving grazing strategy and not mechanical treatments. Since soil condition is almost near reference, implementing additional plan components above Alternative A would not improve soil condition and productivity except in the 1% impaired soils. Overall, implementation of alternatives B, C, D would improve soil condition and productivity faster than alternative A.

Under the current plan, management of riparian areas would continue in accordance with direction in the 1987 Forest Plan (as amended). Although current plan direction is lacking or vague, it is sufficient to maintain soil condition and productivity equal to implementing proposed direction in Alternatives, B, C, and D and trend towards desired conditions would remain static.

Wetland/Cienega PNVT

An environmental consequences analysis of riparian function comparing implementation of forest plan components by alternative can be found in the Riparian Specialist Report, Steinke, 2011).

The following analysis compares implementing plan components by alternative as it relates to soil condition and productivity.

Alternative A

Comparison of current, reference and projected future conditions: Soil condition is highly departed (5% satisfactory soils), and soil productivity is moderately departed from reference conditions in unfenced wetlands. This is not expected to change because herbivory by elk is not expected to change. Wetlands excluded from any grazing trend rapidly towards satisfactory soil

conditions and improved soil productivity. Unfenced wetlands, however, are expected to remain departed from reference conditions.

Projected future condition and trends: Under current management, both soil condition and productivity are projected to remain static in the future due to herbivory by cattle and elk. Herbivores are attracted to isolated water sources and the associated vegetation, particularly during drought conditions. Although management of cattle and fencing of wetlands from herbivores can improve soil condition over a portion of the PNVT, herbivory will maintain unsatisfactory soil conditions over the majority of these wetlands. Elk numbers are predicted to remain relatively static. Litter, vegetation composition, and understory productivity are expected to remain about the same.

Alternatives A, B, C and D

The current plan forest-wide goal of attaining all areas in satisfactory condition is unrealistic and unattainable under current budget authority. . For this individual PNVT, the goal of attaining all areas in satisfactory condition by 2020 would be very difficult to attain under current budget authority unless heavy emphasis and project funding would target this PNVT. Current rate of implementation for soil improvement in this PNVT is very low and centered largely on improving grazing strategy and not mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement would be very limited, and on an opportunity basis.

Under the current plan, management of wetlands would continue in accordance with direction in the 1987 Forest Plan (as amended). Wetland direction is lacking or vague and does not provide clear direction to maintain or restore wetlands toward revised plan (Alts B, C, and D) desired condition and objectives of maintaining or improving soil condition towards satisfactory condition or sustaining soil function where the soil has the ability to resist erosion, infiltrate water and recycle nutrients. Over the last 10 years, only a few wetlands have been restored and most due to settlements stemming from range Allotment planning NEPA.

Alternative B, C, and D treatments would include plan components that would move wetlands and cienegas towards identified desired conditions. Soil function is sustained and in satisfactory soil condition on most acres. In addition, a guideline directing identification of a vegetated streamside management zone, maintenance of 80% herbaceous cover and limited and localized soil compaction and trampling of vegetation should be to the extent where permanent damage to perennial plant would not occur resulting in maintenance of soil cover, reduced sheet erosion, and improved nutrient cycling and soil productivity. The objective of restoration of 5-10 wetlands/10 years would improve at least 15-30% of total wetlands over 10 years and proportionally more per plan life of 15 years.

Implementation of plan components under Alternatives B, C, and D, would indirectly cause the following scenario to occur. Riparian vegetation would improve aiding in the ability to filter sediments, improve soil structure, improve water retention and ground water recharge and develop root masses that stabilize against cutting action associated with high water flow, thereby reducing erosion, improving water quality and maintaining soil productivity.

Continuing implementation of Alternative A would probably not maintain or improve soil condition or productivity or move a large number of wetlands to identified desired conditions as quickly as Alternatives B, C, and D.

Desert Communities PNVT

Alternative A

The soil condition in this PNVT is moderately departed (about 54% in satisfactory condition) with a static trend. There is declined nutrient cycling, reduced ability to infiltrate water, and the inability of soil to resist erosion.

Soil productivity has a moderate departure and a static projected future trend. Soil productivity is very low overall with very low surface litter and very low understory and forage productivity. Current grazing strategies and restricted cross-country Off Highway Vehicle travel should very slowly move soil organics and vegetative production towards reference condition with normal precipitation. Soil conditions, however, would remain static with continued drought.

Projected future condition and trends: Under current management and plan direction, soil condition is projected to remain impaired or unsatisfactory with a static trend over the next couple of decades due to high level of soil disturbance and limited annual precipitation received especially if drought persists. The forest-wide goal of attaining all areas in satisfactory condition is unrealistic and unattainable under current budget authority. However, the goal of attaining all areas in this PNVT in satisfactory condition by 2020 would be very difficult to attain under current budget authority unless heavy emphasis and project funding would target this PNVT. Current rate of implementation for soil improvement in this PNVT is very low and centered largely on improving grazing strategy and not mechanical treatments. Without specific plan emphasis and objectives targeting Desert PNVTs, soil improvement would be very limited, slow and on an opportunity basis. Under current plan direction, litter, vegetation composition, and understory productivity are expected to remain about the same over the short and long term.

Alternative B, C and D

None of the Alternatives have objectives to specifically treat the Desert PNVT. However, Alterntaives B, C and D have an overall forest-wide soil objective of maintenance and improvement of soil condition on 100,000 – 350,000 acres within 10 years although most of those acres would likely occur in the Ponderosa Pine PNVT and probably very little in this PNVT except in high priority watersheds as opportunity arises. It is difficult to predict how many , if any, 6^{th} HUC priority watersheds could be treated in the next 10 years in this PNVT but likely most treatments would occur in the Ponderosa Pine, Pinyon-juniper, Montane Meadow, Great Basin Grasslands or Semidesert grassland PNVTs.

Implementing plan direction in Alterative B, C, and D have desired conditions and guidelines where erosion occurs below threshold levels, is not accelerated and shows little sign of compaction. In addition, biological soils crusts would be present to improve nutrient cycling and stabilize soils and excessive ground disturbance on calcareous soils would be avoided to limit churing highly erodible calcareous sol to the surface exposing it to high rates of wind erosion and durface infertility.

Therefore, implementing plan direction for all Alternatives B, C, and D should equally result in very slow improvement over the plan life as a result of improved grazing strategies, road decommissioning and removal of OHV in erodible soils. Soil improvement would be slow due to the arid climate and lack of plan emphasis on treating this PNVT.

Implementation of plan direction in Alternatives A, B, C, and D would equally move and at the same rate the soil resource to the identified desired conditions.

Overall, compared to Alternative A, implementing management direction in Alts A, B, C, and D would equally improve the ability of the soil to resist erosion, infiltrate water, recycle nutrients.

Semi-Desert Grasslands PNVT

Alternative A.

Comparison of current and reference conditions: Both soil condition and soil productivity are highly departed from reference conditions (only about 4% satisfactory soils) due to historic and current grazing strategies, lack of fire, scattered trees (juniper-grassland ecotones), and improperly located roads.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected to slowly move towards reference or desired conditions, as improved grazing strategies are implemented and roads are closed. Soil improvement would be slow due to the arid climate and lack of plan emphasis on treating this PNVT. This trend will be also slowed due to the continued lack of fire. Under current plan direction, litter, vegetation composition, and understory productivity are expected to slowly improve in the short and long term.

The forest-wide goal of attaining all areas in satisfactory condition is unrealistic and unattainable under current budget authority. For this PNVT, the goal of attaining all areas in satisfactory condition by 2020 would be very difficult to attain under current budget authority unless heavy emphasis and project funding would target this PNVT. Current rate of implementation for soil improvement in this PNVT is very low and centered largely on improving grazing strategy and not mechanical treatments. Without specific plan emphasis and objectives targeting Semidesert PNVTs, soil improvement would be very limited, slow and on an opportunity basis.

Alternative B, C and D

Alternatives B, C, D have desired conditions and objectives to treat (see table 2) at a rate of 3500 acres in 10 years plus the overall forest-wide soil objective of maintenance and improvement of soil condition on 100,000 – 350,000 acres within 10 years although most of those acres would likely occur in the Ponderosa Pine PNVT. Since there are about 86,000 acres of impaired or unsatisfactory soils in these PNVTs, it would take decades to treat all and reach desire conditions. Alts B, C and D have additional plan components directing treatment of impaired and unsatisfactory soils such that they are trending towards satisfactory soil conditions both within and out of high priority watersheds.

Therefore, implementing plan direction for Alts B, C and D would move these PNVTs towards desired conditions a little faster than A. In areas treated, the following scenario would occur, soil productivity and function would improve and function normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved or maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be improved and minimized due to improved plant productivity.

Alternative A does not have PNVT specific objectives, soil improvement would occur on an opportunity basis, likely far less than in Alternatives B, C and D and based on recent trend, would continue to slowly move towards desired conditions. Under Alternative A, soil condition would not improve as quickly as implementing plan direction in Alternatives B, C and D.

In addition, Alternatives B, C and D could concentrate treatments in focus watersheds needed soil improvement, which allow a better opportunity for restoring or maintaining watershed and soil condition in these PNVTs because these PNVTs have some of the poorest soil conditions of the forest.

Implementing direction for Alternatives B, C, and D would result in soil improvement projects including mechanical thinning with lop and scatter, herbicide or prescribed fire treatments of invaded woody species that would have the following indirect consequences; would result in improved herbaceous understories biomass, protective vegetative ground cover, reduced soil erosion, improved water quality and soil productivity.

In addition, implementing plan direction in Alternatives B, C, specific direction would require maintenance of soil hydrologic function including desired conditions maintaining effective herbaceous and vegetative ground cover, soil stability and nutrient cycling resulting in minimal erosion and compaction and a diversity of grass and forbs at or near potential. In addition, biological soils crusts would be present to improve nutrient cycling and stabilize soils.

Implementation of plan direction in Alternatives B, C, and D would equally move and at the same rate the soil resource to the identified desired conditions.

Overall, compared to Alternative A, implementing management direction in Alts B, C, and D would equally improve the ability of the soil to resist erosion, infiltrate water, recycle nutrients and move towards desired conditions a little faster than A. Under Alternative A, soil condition and productivity would not improve as quickly as implementing plan direction in Alternatives B, C and D.

Interior Chaparral PNVT

Alternative A

Comparison of current, reference and projected future conditions: Both the current soil condition and soil productivity are similar to reference condition with high amounts of satisfactory soils (near 100%). This is not projected to change in the future.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected to remain static. Litter, vegetation composition, and understory productivity are expected to remain about the same. The goal of attaining all areas in satisfactory condition has for the most part, already been attained.

Alternative B, C and D

From a soil condition and productivity standpoint, the identified desired conditions have for the most part, already been met. No specific plan objectives are needed or included in the revised

plan Alternatives B, C, and D to maintain soil productivity. Implementing direction for desired conditions in B, C, and D would emphasize maintenance of vegetative ground cover. Sufficient protective vegetative ground cover (35-45%) would be maintained to protect soil from accelerated erosion and therefore would maintain soil productivity. Soil nutrient cycling would be improved through maintenance of biological soil crusts. There is a guideline that directs fire treatments to maintain diversity of habitat and plant community in seral stages that would indirectly improve soil nutrient cycling and reduce the risk of moderate severity wildfires that may pose risk to soil productivity, connected waters and water quality.

Trend under current plan direction of soil condition and productivity is static. Implementing additional plan direction under Alternatives B, C, and D, would better assure soil condition and productivity are maintained and moving towards desired conditions compared to Alternative A.

Piñon-Juniper with Grass PNVT

Alternative A.

Comparison of current, reference and projected future conditions: There is a low departure for both soil condition (about 72% in satisfactory condition) and soil productivity with trends generally away from desired or reference conditions especially where the canopy is more than about 30%. The lack of fire has also contributed to the development of areas with high canopy cover and a loss of herbaceous understory. Herbaceous understory helps hold soil in place and carries fire. Consequently, structure, composition and processes are departed from reference conditions.

Projected future condition and trends:The current plan has a goal to put all soils in satisfactory soil condition that are currently not in satisfactory soil condition by 2020. Pinyon-juniper implementation rates for tree reduction are not set objectives in the current plan. Current management, treatment rates are about 900 acres/year or 0.003 % of the PNVT/yr. At this rate, it would take over one hundred years to thin all unsatisfactory and impaired soils. Similar to the Piñon Juniper Evergreen Shrub PNVT, many areas are eroding faster than they are renewing themselves putting soil productivity at risk. It takes dozens of years to build one inch of soil in this PNVT. Overall, soil condition is projected to move slowly away from reference condition except in areas where the trees have been thinned. In thinned areas, soil condition should move towards reference condition with the return of an herbaceous understory.

Under the current plan and applicable components, soil condition and productivity are projected to move away from reference or desired conditions, as tree canopy cover continues to increase reducing herbaceous understory and sol condition and productivity. Any Soil improvement would be slow due to the arid climate and lack of plan emphasis on treating this PNVT. This trend will be also slowed due to the continued lack of fire. Under current plan direction, litter, vegetation composition, and understory productivity are expected to remain about the same in the short and long term.

The goal of attaining all areas in satisfactory condition would be very difficult under current budget authority unless heavy emphasis and project funding would target this PNVT. Current rate of implementation for soil improvement in this PNVT is low and centered largely on improving grazing strategy and only limited mechanical treatments. Without specific plan emphasis and

objectives targeting this PNVT, soil improvement would be very limited, slow and on an opportunity basis.

Alternatives B, C, and D

Alternatives B, C, D have desired conditions and objectives to treat the Pinyon Juniper PNVTs (see table 4) at a rate of 1000 – 10,000 acres in 10 years plus the overall forest-wide soil objective of maintenance and improvement of soil condition on 100,000 – 350,000 acres within 10 years although most of those acres would likely occur in the Ponderosa Pine PNVT. Since there are about 75,000 acres of impaired or unsatisfactory soils in these PNVTs, it would take decades to treat all and reach desire conditions. Alts B, C and D have additional forest-wide plan components directing treatment of impaired and unsatisfactory soils such that they are trending towards satisfactory soil conditions both within and out of high priority watersheds.

Alternatives, B, C and D desired conditions that would require management and allow natural disturbances to result in sufficient organic ground cover and native herbaceous vegetation that protects soil from accelerated erosion and compaction, and contributes to ecosystem diversity sufficient to maintain desired tree density, coarse woody debris and soil nutrient cycling. Managing ground cover and tree density to meet these desired outcomes would improve soil condition trend and move this PNVT slowly towards desired condition in this PNVT whereas Alternative A would trend away due to lack of treatment emphasis.

Therefore, implementing plan direction for Alts B, C and D would move these PNVTs slowly towards desired conditions. In areas treated, the following scenario would occur, soil productivity and function would improve and function normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved or maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be improved and minimized due to improved plant productivity.

Alternative A does not have PNVT specific objectives and soil improvement would occur only on an opportunity basis, likely far less than in Alternatives B, C and D and based on recent trend, would continue to move away from desired conditions. Under Alternative A, soil condition would not improve as quickly as implementing plan direction in Alternatives B, C and D.

In addition, Alternatives B, C and D concentrate treatments in focus watersheds needed soil improvement, which allow a better opportunity for restoring or maintaining watershed and soil condition in these PNVTs because these PNVTs have some of the poorest soil conditions of the forest.

PNVT specific direction for all Pinyon-juniper types direct presence of sufficient plant litter and coarse woody material to resist accelerated erosion and essential to promote nutrient cycling (USDA Forest Service, 1994) and water retention that should result in maintenance and improvement of soil condition and productivity. In addition, biological soils crusts would be present to improve nutrient cycling and stabilize soils.

Implementing direction and guidelines for Alternatives B, C, and D would result in soil improvement projects including mechanical thinning, lop and scatter, treatement of encroached grasslands, maintenance of previously converted areas on grassland soil types and reduction of

hazardous fuels through prescribed or resource benefit fires that would have the following indirect consequences; would result in improved herbaceous understories biomass, protective vegetative ground cover, reduced soil erosion, and improved soil In addition, implementing direction for Alts B, C, and D includes greater emphases on use of wildfire to meet resource objectives. This should result in a reduction of hazardous fuels that pose risk to watershed condition and water quality from potential uncharacteristic wildfires that generally result in large areas of high burn severity.

Implementation of plan direction in Alternatives B, C, and D would equally move and at the same rate the soil resource to the identified desired conditions.

Overall, compared to Alternative A, implementing management direction in Alts B, C, and D would equally improve the ability of the soil to resist erosion, infiltrate water, recycle nutrients. Under Alternative A, soil condition and productivity would probably not improve and probably move away compared to implementing plan direction in Alternatives B, C and D.

Piñon-Juniper Evergreen Shrub and Pinyon-Woodland (Persistent) PNVT

Alternative A

Comparison of current, reference and projected future conditions: There is a moderate departure for both PNVTs soil condition (about 40% in satisfactory condition) and soil productivity with trends generally away from desired or reference conditions especially where the canopy is more than about 30%. The lack of fire has also contributed to the development of areas with high canopy cover and a loss of herbaceous understory particularly in the PJ Evergreen Shrub PNVT. Herbaceous understory helps hold soil in place and carries fire. Due to rockier and droughtier soils and subsequent reduced herbaceous vegetative layer, the PJ Persistent PNVT, is less likely to carry a ground fire and more likely to contain older, denser tree stands. However, canopies above about 30% have reduced the herbaceous understory, vegetative ground cover and soil condition and productivity on this PNVT also. Consequently, structure, composition and processes are departed from reference conditions.

Projected future condition and trends: Under current management, treatment rates are about 900 acres/year or 0.003 % of the PNVT/yr. At this rate, it would take over one hundred years to thin all unsatisfactory and impaired soils. Similar to the Piñon Juniper Evergreen Shrub PNVT, many areas are eroding faster than they are renewing themselves putting soil productivity at risk. It takes dozens of years to build one inch of soil in this PNVT. Overall, soil condition is projected to move away from reference condition except in areas where the trees have been thinned. In thinned areas, soil condition should move towards reference condition with the return of an herbaceous understory.

Under the current plan and applicable components, soil condition and productivity are projected to move away from reference or desired conditions, as tree canopy cover continues to increase reducing herbaceous understory and soil condition and productivity. Any Soil improvement would be slow due to the arid climate and lack of plan emphasis on treating this PNVT. This trend will be also slowed due to the continued lack of fire. Under current plan direction, litter,

vegetation composition, and understory productivity are expected to remain the same in the short and long term.

Alternative A has a goal to put all soils in satisfactory soil condition that are currently not in satisfactory soil condition by year 2020. Piñon juniper implementation rates for tree reduction, however, are not objectives in the 1987 plan. Current management, treatment rates are about 900 acres per year or 0.003 percent of the PNVT per year. At this rate, it would take over 100 years to thin all unsatisfactory and impaired soils. Many areas are eroding faster than they are renewing themselves putting soil productivity at risk. It takes dozens of years to build one inch of soil in this PNVT. Overall, soil condition is projected to move slowly away from desired condition except in areas where the trees have been thinned. In thinned areas, soil condition should move toward desired condition with the return of an herbaceous understory.

Under alternative A, soil condition and productivity are projected to move away from desired conditions, as tree cover continues to increase reducing herbaceous understory and soil condition and productivity. Any soil improvement would be slow due to the arid climate and lack of plan emphasis on treating this PNVT. This trend would also be slowed due to the continued lack of fire. Under alternative A, litter, vegetation composition, and understory productivity are expected to remain about the same in the short and long term.

Current rate of implementation for soil improvement in this PNVT is low and centered largely on improving grazing strategy and only limited mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement would be very limited and slow.

The goal of attaining all areas in satisfactory condition by 2020 would be very difficult to attain under current budget authority unless heavy emphasis and project funding would target this PNVT. Current rate of implementation for soil improvement in this PNVT is low and centered largely on improving grazing strategy and only limited mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement would be very limited, slow and on an opportunity basis.

Alternatives B, C, and D

Alternatives B, C, D have desired conditions and objectives to treat the Pinyon Juniper PNVTs (see table 2) at a rate of 1000 – 10,000 acres in 10 years plus the overall forest-wide soil objective of maintenance and improvement of soil condition on 100,000 – 350,000 acres within 10 years although most of those acres would likely occur in the Ponderosa Pine PNVT.. Since there are about 200,000 acres of impaired soils in these PNVTs, it would take decades to treat all and reach desire conditions. Alts B, C and D have additional plan components directing treatment of impaired and unsatisfactory soils such that they are trending towards satisfactory soil conditions both within and out of high priority watersheds.

PNVT specific direction for all Pinyon-juniper types direct presence of sufficient plant litter and coarse woody material to resist accelerated erosion and promote nutrient cycling (USDA Forest Service, 1994) and water retention that should result in maintenance and improvement of soil condition and productivity. In addition, biological soils crusts would be present to improve nutrient cycling and stabilize soils.

Therefore, implementing plan direction for Alts B, C and D would move these PNVTs slowly towards desired conditions. In areas treated, the following scenario would occur, soil productivity and function would improve and function normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be minimized due to improved plant productivity.

Alternative A does not have PNVT specific objectives and soil improvement would occur only on an opportunity basis, likely far less than in Alternatives B, C and D and based on recent trend, would continue to move away from desired conditions. Under Alternative A, soil condition would not improve as quickly as implementing plan direction in Alternatives B, C and D.

In addition, Alternatives B, C and D concentrate treatments in focus watersheds needed soil improvement, which allow a better opportunity for restoring or maintaining watershed and soil condition in these PNVTs because these PNVTs have some of the poorest soil conditions of the forest.

PNVT specific direction for all Pinyon-juniper types direct presence of sufficient plant litter and coarse woody material to resist accelerated erosion and promote nutrient cycling and water retention that should result in maintenance and improvement of soil condition and productivity. In addition, biological soils crusts would be present to improve nutrient cycling and stabilize soils.

Implementing direction for Alternatives B, C, and D would result in soil improvement projects including mechanical thinning and reduction of hazardous fuels through prescribed or resource benefit fires that would have the following indirect consequences; would result in improved herbaceous understories biomass, protective vegetative ground cover, reduced soil erosion, and improved soil In addition, and for the Pinyon-Juniper Evergreen shrub PNVT, implementing direction for Alts B, C, and D includes greater emphases on use of wildfire to meet resource objectives. This should result in a reduction of hazardous fuels that pose risk to watershed condition and water quality from potential uncharacteristic wildfires that generally result in large areas of high burn severity.

For the Piñon Juniper Evergreen Shrub PNVT, implementing direction for alternatives B, C, and D includes greater emphases on use of wildfire to meet resource objectives. This should result in a reduction of hazardous fuels that pose risk to watershed condition and water quality from potential uncharacteristic wildfires that generally result in large areas of high burn severity.

Forestwide, implementation of plan direction in alternatives B, C, and D would equally move and at the same rate the soil resource to the identified desired conditions. Overall, compared to alternative A, implementing management direction in alternatives B, C, and D would equally improve the ability of the soil to resist erosion, infiltrate water, and recycle nutrients. Under alternative A, soil condition and productivity would probably move away compared to whereas

Ponderosa Pine PNVT

Alternative A

Comparison of current, reference and projected future conditions: There is currently a low departure from reference or desired condition. Soils are almost all in satisfactory condition (99%). Although the forest is overstocked and herbaceous understory reduced compared to reference conditions, the amount of protective duff layer is more than adequate to protect against accelerated erosion and loss of soil productivity. Because herbaceous understory is somewhat reduced, nutrient cycling is nearly impaired. The risk of wildfire resulting in large areas of high burn severity can be high during spring and summer months that could result in appreciable loss of soil and productivity and risk degradation of water quality along connected streams. Projected trends are static for both soil condition and soil productivity.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected remain static from reference or desired conditions. The overall projected trend is static, but the areas of dense trees and high canopy closure are vulnerable to unnatural wildfire. . Projected trends under alternative A are static for both soil condition and soil productivity, but the areas of dense trees and high canopy closure are vulnerable to uncharacteristic wildfire. High burn severity fires would pose a risk to soil condition and watershed condition in areas where soils have a moderate to high erosion hazard, which account for nearly a third of the PNVT.

High burn severity fires pose a risk to soil condition and watershed condition in areas where soils have a moderate to high erosion hazard, which account for nearly a third of the PNVT.

Taking into account the potential for landscape level watershed degradation following wildfire disturbances, the risk of trending away following wildfire in soil condition and productivity is about one-third of this PNVT based on the soils with moderate or high erosion hazard. In open areas, or areas that are treated, herbaceous understory and nutrient cycling function would improve to satisfactory condition in treated areas and remain static in untreated areas. Overall, soil condition and productivity is projected to remain static.

Current plan implementation rates for mechanical thinning in this PNVT averages less acres/year compared to Alternatives B, C and D. Average acres treated with resource benefit fires is about 86,200 acres/10 years and 160,000 acres under prescribed fire (Vegetation and Fire Specialist Report, Martin, 2013).

Litter, vegetation composition, and understory productivity are expected to remain about the same. The goal of attaining all areas in satisfactory condition has for the most part, already been attained. Current implementation of hazardous fuel reduction is moving these PNVT towards vegetative desired conditions and improving herbaceous understory along with soil condition and productivity.

Alternatives B, C and D

From a soil condition and productivity standpoint, the identified desired conditions have for the most part, already been met. From a vegetative desired condition standpoint, desired condition has not been met (see vegetation specialist report, Martin, 2013). Even though this PNVT is dominated by satisfactory soil conditions, additional maintenance is required to improve soil condition even closer to identified desired conditions, improve nutrient cycling and reduce the

Alternatives B, C, and D have plan desired conditions and 10-year objectives to treat the Ponderosa Pine PNVT: over 50,000 to 260,050 acres, prescribe fire over 150,000 to 300,000 acres, and 135,000 acres of wildland fires to meet resource objectives, plus the overall forestwide soil objective of maintenance and improvement of soil condition on 100,000 to 350,000 acres within 10 years and most of those acres would likely occur in the Ponderosa Pine PNVT.

As stated in the beginning of this section, plan direction under all Alternatives have similar plan components desired conditions for soil productivity and condition except desired conditions under Alts B, C, and D include more emphasis on protecting soil productivity and function though natural and human disturbances . Additional and more soil and PNVT specific plan language under Alternatives B, C, and D include desired outcomes that would better sustain soil function compared to Alternative A. Alternatives, B, C and D desired conditions would require management of human disturbances and allow natural disturbances to result in sufficient organic ground cover and native herbaceous vegetation that protects soil from accelerated erosion and compaction, and contributes to ecosystem diversity sufficient to maintain desired tree density, coarse woody debris and soil nutrient cycling. Managing ground cover and tree density to meet these desired outcomes would improve soil condition trend in this PNVT whereas Alternative A would remain static

Implementing plan direction objectives for resource benefit fire and at the high end of the prescribed fire range would result in faster maintenance, protection and improvement of soil condition and productivity compared to Alternative A. Implementing plan objectives at the lower end of plan rates for prescribed fire would result in slower maintenance, protection and improvement of soil condition and productivity and be similar to Alternative A

Trend under current plan direction of soil condition and productivity is static. Continuing implementing current plan direction would treat fewer acres and at a slower rate compared to plan direction proposed under Alternatives B, C and D. From a soil resource standpoint, this would indirectly result in slower maintenance and improvement of stand structure resulting in less improvement of the herbaceous understory vegetation and soil nutrient cycling function, and indirectly cause higher risk of uncharacteristic wildfire that poses risk to soil productivity and water quality.

Alternative A has Ponderosa Pine specific objectives and soil improvement would continue to occur simultaneously with current rate of treatments of mechanical harvesting, use of prescribed fire and other soil resource improvement projects. However, the rate would likely be less than in Alternatives B, C and D. Recent soil condition and productivity trend is static because the soil surface has adequate ground cover to reduce accelerated erosion. However, implementing plan direction for Alts B, C, and D would improve soil nutrient cycling towards identified desired conditions better than Alt A.

Implementing plan direction for Alts B, C and D would move this PNVT even closer towards desired conditions compared to Alt. A. In areas treated, the following scenario would occur, soil productivity and function would improve even within the satisfactory condition class and function normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved or maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be minimized due to plant diversity.

In addition, Alternatives B, C and D concentrate treatments in focus watersheds needed soil improvement, which allow a better opportunity for restoring or maintaining watershed and soil condition in this PNVT because there is high emphasis to treat this PNVT due to high wildfire risk and potential for increased biomass production that may contribute to local economic sustainability.

In addition, implementing direction for desired conditions in B, C, and D would emphasize maintenance of vegetative ground cover sufficient to protect soil against accelerated erosion, promote water infiltration, and maintain woody material that contributes to long term soil productivity (USDA Forest Service, 1994). B, C, and D would strive to create a landscape where low severity wildfires are characteristic for the PNVT resulting in lower risk to downstream water quality and maintenance of soil productivity.

Implementing direction for Alternatives B, C, and D would result in soil improvement projects including mechanical thinning and reduction of hazardous fuels through prescribed or resource benefit fires that would have the following indirect consequences; would result in improved herbaceous understories biomass, protective vegetative ground cover, reduced soil erosion, and improved soil In addition, implementing direction for Alts B, C, and D includes greater emphases on use of fire to meet resource objectives. This plays a large role and should result improved herbaceous understory growth improving soil condition and productivity and a reduction of hazardous fuels that pose risk to watershed condition and water quality from potential uncharacteristic wildfires that generally result in large areas of high burn severity.

Implementing desired conditions and objectives under Alternatives B, C, and D that result in lower tree densities could cause short term increase in water yield to connected streamcourses, springs and groundwater but would be expected to last less than 10 years according to research (USDA Forest Service, 1979, Baker etl al, ERI).

Implementing plan direction would reduce hazardous fuels and associated risk of high burn severity stemming from overstocked forests and wood lands and consequently would reduce the risk of accelerated erosion and sediment delivery into connected streamcources thus maintaining water quality.

Implementation of plan direction in alternatives B, C, and D would equally move and at the same rate the soil resource to the identified desired conditions

Implementing management direction in alternatives B, C, and D would equally maintain or improve the ability of the soil to resist erosion, infiltrate water, and recycle nutrients. Under alternative A, soil condition and productivity would remain static or not improve as quickly as implementing plan direction in alternatives B, C, and D.

Mixed Conifer (Frequent Fire and with Aspen) PNVT

Alternative A

Comparison of current, reference and projected future conditions: From a soil condition and soil productivity standpoint, these 2 PNVTs are similar. These PNVTs have mostly satisfactory soil condition (>95%) and are similar to desired or reference conditions and therefore have low

departure. Soil productivity is also similar to reference conditions. Projected future trends for both soil condition and productivity are static. Alternative A 's forestwide goal of attaining all areas in satisfactory condition has for the most part, already been attained, and projected future trends for both soil condition and productivity are static since litter, vegetation composition, and understory productivity are expected to remain about the same.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected to remain static from reference or desired conditions. The overall projected trend is static.

In the Mixed Conifer with Frequent Fire, the fire regime is believed to be more frequent than the Mixed Conifer with Aspen and closely approximates the Ponderosa Pine PNVT with respect to potential degradation of soil condition and productivity. Conditions in Mixed Conifer with Frequent Fire, consequently, could pose a risk to connected waters and water quality in the event of a large wildfire.

High burn severity fires pose a risk to soil condition and watershed condition in areas where soils have a moderate to high erosion hazard, which account for more than half of these PNVTs (USDA, 2013).

Litter, vegetation composition, and understory productivity are expected to remain about the same. The goal of attaining all areas in satisfactory condition has for the most part, already been attained.

Alternative A would allow fire treatments on fewer acres and at a slower rate compared to plan direction proposed under alternatives B, C, and D. From a soil resource standpoint, this would indirectly result in slower maintenance and improvement of stand structure resulting in less improvement of the herbaceous understory vegetation and soil nutrient cycling function, and indirectly cause higher risk of uncharacteristic wildfire that poses risk to soil productivity and water quality.

Alternatives B, C and D

From a soil condition and productivity standpoint, the identified desired conditions have for the most part, already been met. Even though both PNVTs are dominated by satisfactory soil conditions, additional maintenance is required to improve soil condition even closer to identified desired conditions (in the frequent fire PNVT) , improve nutrient cycling and reduce the risk of uncharacteristic wildfires that pose a risk to soil productivity and water quality.

For Mixed Conifer Frequent Fire

Alternatives B, C, D have plan desired conditions and objectives to use low severity fire in the frequent fire PNVT on up to 8000 acres/10 years and 7500 acres/10 years for resource benefit fires plus the overall forest-wide soil objective of maintenance and improvement of soil condition on 100,000 – 350,000 acres within 10 years although most of those acres would likely occur in the Ponderosa Pine PNVT. Recent soil condition and productivity trend is static because the soil surface has adequate ground cover to reduce accelerated erosion. However, implementing plan direction for Alts B, C, and D would improve soil nutrient cycling and towards identified desired conditions better than Alt A and at a slow rate.

Trend under current plan direction of soil condition and productivity is static. Continuing implementing current plan direction would allow fire treatments on fewer acres and at a slower rate compared to plan direction proposed under Alternatives B, C and D. From a soil resource standpoint, this would indirectly result in slower maintenance and improvement of stand structure resulting in less improvement of the herbaceous understory vegetation and soil nutrient cycling function, and indirectly cause higher risk of uncharacteristic wildfire that poses risk to soil productivity and water quality.

In the Mixed Conifer Frequent Fire PNVT, implementing plan direction for Alts B, C and D would move this PNVT a little closer towards desired conditions compared to Alt. A. In areas treated with fire, the following scenario would occur, soil productivity and function would improve even within the satisfactory condition class and function normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved or maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be minimized due to plant diversity.

In addition, implementing direction for desired conditions in B, C, and D would emphasize maintenance of vegetative ground cover sufficient to protect soil against accelerated erosion, promote water infiltration, and maintain coarse woody material that contributes to long term soil productivity (USDA Forest Service, 1994). B, C, and D would strive to create a landscape where low severity wildfires are characteristic for the PNVT (high severity could occur on a rare basis in Mixed Conifer with Aspen) resulting in lower risk to downstream water quality and maintenance of soil productivity.

Implementing direction for Alternatives B, C, and D (reduction of hazardous fuels) through prescribed or resource benefit fires would have the following indirect consequences; would result in improved herbaceous understories biomass, protective vegetative ground cover, reduced soil erosion, and improved soil. Allowing low severity fire plays a large role and should result improved herbaceous understory growth improving soil condition and productivity and a reduction of hazardous fuels that pose risk to watershed condition and water quality from potential uncharacteristic wildfires that generally result in large areas of high burn severity.

Alternatives B, C, and D would equally and slowly move (because implementation would be at a slow rate) and at the same rate the soil resource to the identified desired conditions.

Implementing management direction in Alts B, C, and D would equally maintain or improve the ability of the soil to resist erosion, infiltrate water, recycle nutrients and slowly move soil condition towards identified desired conditions. Under Alternative A, soil condition and productivity would remain static or not improve as quickly as implementing plan direction in Alternatives B, C and D.

Mixed Conifer with Aspen PNVT

Desired conditions for soil condition and productivity are similar to Mixed Conifer (frequent fire). Quaking aspen stand would be maintained in a mosaic pattern which is improved direction compared to the current plan. In the plan direction for this PNVT and elsewhere, there is improved direction for aspen in alternatives B, C, and D, however, compared to alternative A, that better clarifies where aspen should generally be found and its role on the landscape.

Alternatives, B, C and D desired conditions would require management and allow natural disturbances to result in sufficient organic ground cover and native herbaceous vegetation that protects soil from accelerated erosion and compaction, and contributes to ecosystem diversity sufficient to maintain desired tree density, coarse woody debris and soil nutrient cycling. Managing ground cover and tree density to meet these desired outcomes would improve soil condition trend in this PNVT whereas Alternative A would remain static. No treatment objectives have been proposed including use of fire in this PNVT.

Compared to Alternative A, implementation of plan direction for Alternatives B, C, and D could improve soil condition and trend and move slowly towards desired conditions.

Montane/Subalpine Grasslands PNVT

Alternative A

Comparison of current, reference and projected future conditions: Soil condition in montane grasslands (TES units except TES 640) is highly departed with static trend and has a low departure with static trend in subalpine grasslands (only TES map unit 640). Overall, about 1/3rd have satisfactory soils and therefore are moderately departured .Soil productivity is moderately departed with a static trend in montane grasslands and has a low departure with a static trend in subalpine grasslands.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected to remain static from reference or desired conditions. The overall projected trend is static.

In the montane grasslands portions where impaired soils are prevalent, areas of impaired soils have reduced soil productivity are expected to remain impaired (static) due to continued grazing, especially by elk. Trends are toward reference condition in isolated areas where grazers are excluded; however, these are in very limited areas of the PNVT.

Currently, both Montane and Subalpine portions have moderate to high overall soil productivity. Montane portions, however, have low to moderate surface litter and low to moderate herbaceous production and, thus, are departed from reference conditions for these two productivity characteristics. Areas of reduced soil productivity are expected to continue in the future due to grazing, especially by elk. Subalpine meadows have litter and understory and forage production near reference conditions. High soil productivity is expected to remain into the future and, thus, has a static trend.

Under current plan direction, litter, vegetation composition, and understory productivity are expected to remain about the same in the short and long term.

The forest-wide goal of attaining all areas in satisfactory condition is unrealistic and unattainable under current budget authority. Current rate of implementation for soil improvement in this PNVT is very low and centered largely on improving grazing strategy and not mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement would be very limited, and on an opportunity basis.

Alternative B, C and D

Alternatives B, C, and D have objectives to specifically treat this PNVT. In addition, alternatives B, C, and D have a forestwide objective of maintenance and improvement of soil condition on 100,000 to 350,000 acres within 10 years. Most of the improvements would probably occur in the Ponderosa Pine PNVT, but some could be targeted in this pnvt.

Alternatives B, C, and D have objectives to treat between 7,600 to 11,400 for the 10 years following plan approval that would assure that soil condition, function is improved and soil productivity maintained on those acres. Overall, the amount of acres that would be treated is between 32 and 48% of total PNVT acres but the result would move these acres toward identified desired conditions equally but faster than Alternative A.Alternatives B, C, and D have an additional guidelines directing maintenance of at least 90 percent protective vegetative ground cover that would protect against accelerated erosion and maintain soil productivity. Since there are only about 16,000 acres of impaired soils in these PNVTs, it would be possible to treat most of the PNVTs over the life of the plan and reach identified desired conditions. Given alternatives B, C, and D have additional plan components directing treatment of impaired and unsatisfactory soils such that they are trending toward satisfactory soil conditions, implementing plan direction for alternatives B, C, and D would move these PNVTs slowly toward desired conditions. In areas treated, soil productivity and function would improve and function normally and properly so that water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved or maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be improved and minimized due to improved plant productivity.

Therefore, implementing plan direction for Alts B, C and D would move these PNVTs slowly towards desired conditions. In areas treated, the following scenario would occur, soil productivity and function would improve and function normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved or maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be improved and minimized due to improved plant productivity.

Alternative A does not have PNVT specific guidelines and soil improvement would occur on an opportunity basis, likely far less than in Alternatives B, C and D and based on recent trend, would continue to slowly move towards desired conditions. Under Alternative A, soil condition would not improve as quickly as implementing plan direction in Alternatives B, C and D.

In addition, Alternatives B, C and D could concentrate treatments in focus watersheds needed soil improvement, which allow a better opportunity for restoring or maintaining watershed and soil condition in these PNVTs because these PNVTs have some of the poorest soil conditions of the forest.

Implementing direction for Alternatives B, C, and D would result in soil improvement projects including mechanical thinning with lop and scatter, herbicide or prescribed fire treatments of invaded woody species that would have the following indirect consequences; would result in improved herbaceous understories biomass, protective vegetative ground cover, reduced soil erosion, improved water quality and soil productivity.

In addition, implementing plan direction in Alternatives B, C, and D would require maintenance of ground cover and herbaceous vegetation sufficient to protect from accelerated erosion, promote water infiltration and nutrient cycling function. Soil function would be sustained. When implemented, the guideline to maintain at least 40% vegetative ground cover would adequately protect soil against accelerated erosion and maintain soil productivity.

Implementation of plan direction in Alternatives B, C, and D would equally move and at the same rate the soil resource to the identified desired conditions.

Overall, compared to Alternative A, implementing management direction in Alts B, C, and D would equally improve the ability of the soil to resist erosion, infiltrate water, recycle nutrients. Under Alternative A, soil condition and productivity would not improve as quickly as implementing plan direction in Alternatives B, C and D.

Great Basin Grassland PNVT

Alternative A.

Comparison of current, reference and projected future conditions: Soil condition is highly departed from reference condition (only 13% satisfactory soils). Soil productivity is moderately departed from reference condition. Both are projected to move slowly towards reference condition under current management. With normal precipitation, surface litter, understory and forage vegetation production, and soil organic matter would improve. Elk grazing, however, may reduce the rate of improvement to a limited extent.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected to move slowly towards reference condition for soil condition and soil productivity. The forest-wide goal of attaining all areas in satisfactory condition is unrealistic and unattainable under current budget authority. Current rate of implementation for soil improvement in this PNVT is low and centered largely on improving grazing strategy and few mechanical treatments. Without specific plan emphasis and objectives targeting this PNVT, soil improvement would be very limited, and on an opportunity basis.

Alternative B, C and D

Alternatives B, C, and D have objectives to treat between 10,800 and 12,400 acres during the 10 years following plan approval that would assure that soil condition, function is improved and soil productivity maintained on those acres. Overall, the amount of acres that would be treated is11.6 to 13% of total PNVT acres but the result would move these acres toward identified desired conditions equally but faster than alternative A.

Since there are about 80,000 acres of impaired or unsatisfactory soils in these PNVTs, it would take more than 10 years to treat the majority and reach desire conditions and probably slowly move towards desired conditions. Alts B, C and D have additional plan components directing treatment of impaired and unsatisfactory soils such that they are trending towards satisfactory soil conditions both within and out of high priority watersheds.

Therefore, implementing plan direction for Alts B, C and D would move these PNVTs slowly towards desired conditions. In areas treated, the following scenario would occur, soil productivity and function would improve and function normally and properly so water infiltrates and disperses properly, withstands accelerated erosion, and recycles nutrients. Herbaceous vegetative cover would be improved or maintained at levels that contribute to suitable hydrologic function, soil stability and nutrient cycling and better adapt to climate change. Compaction and erosion would be improved and minimized due to improved plant productivity.

Alternative A does not have PNVT specific objectives and soil improvement would occur on an opportunity basis, likely far less than in Alternatives B, C and D and based on recent trend, would continue to slowly move towards desired conditions. Under Alternative A, soil condition would not improve as quickly as implementing plan direction in Alternatives B, C and D.

In addition, Alternatives B, C and D could concentrate treatments in focus watersheds needed soil improvement, which allow a better opportunity for restoring or maintaining watershed and soil condition in these PNVTs because these PNVTs have some of the poorest soil conditions of the forest.

Implementing direction for Alternatives B, C, and D would result in soil improvement projects including mechanical thinning with lop and scatter, herbicide or prescribed fire treatments of invaded woody species that would have the following indirect consequences; would result in improved herbaceous understories biomass, protective vegetative ground cover, reduced soil erosion, improved water quality and soil productivity.

In addition, implementing plan direction in Alternatives B, C, and D would require maintenance of ground cover and herbaceous vegetation sufficient to protect from accelerated erosion, promote water infiltration and nutrient cycling function. Soil function would be sustained. When implemented, the guideline to maintain 25-45% vegetative ground cover would adequately protect soil against accelerated erosion and maintain soil productivity. Historic fire regimes of 1 – 35 years would be of low severity, burn in a mosaic pattern and probably only carry on soil types with loamy surfaces and less clay (non-Vertic subgroups) since the soils with high amounts of clay produce much less vegetative biomass that is needed to carry a ground fire.

Implementation of plan direction in Alternatives B, C, and D would equally move and at the same rate (slowly towards) the soil resource to the identified desired conditions.

Overall, compared to Alternative A, implementing management direction in Alts B, C, and D would equally improve the ability of the soil to resist erosion, infiltrate water, recycle nutrients. Under Alternative A, soil condition and productivity would not improve as quickly as implementing plan direction in Alternatives B, C and D.

Spruce Fir PNVT

Alternative A.

Comparison of current, reference and projected future conditions: The satisfactory soil conditions (near 100%) are little changed between historic and current conditions. These soils have high amounts of vegetative ground cover to prevent accelerated erosion. Likewise, soil productivity is

similar to reference conditions. Soil is functioning normally, and maintaining levels necessary to sustain ecological systems. There is a static trend from current condition to projected future soil condition and productivity.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected to remain static. Litter, vegetation composition, and understory productivity are expected to remain about the same. The goal of attaining all areas in satisfactory condition has for the most part, already been attained.

Alternative A, B, C and D

From a soil condition and productivity standpoint, the identified desired conditions have for the most part, already been met. No specific plan objectives are needed or included in the revised plan Alternatives B, C, and D to maintain soil productivity. There is a guideline that directs minimal and confined soil and vegetation disturbance from management activities to maintain soil productivity and 6th HUC watershed condition in class 1 (functioning condition).

Implementing direction for desired conditions in B, C, and D would emphasize maintenance of vegetative ground cover sufficient to protect soil against accelerated erosion, promote water infiltration, and maintain coarse woody material that contributes to long term soil productivity (USDA Forest Service, 1994). B, C, and D would strive to create a landscape where mixed and some high severity wildfires are characteristic for the PNVT and function to maintain stand density, structure and plant composition. High severity fires could infrequently occur but not to the extent where it would risk long-term impairment to connected waters downstream or caused loss of productivity over major portions of the 5th or 6th HUC watershed. Quacking aspen stand would be maintained in a mosaic pattern which is improved direction compared to the current plan.

Trend under current plan direction of soil condition and productivity is static. Similar to Alternative A, there are no specific treatments including mechanical or prescribed fire, identified in plan direction under Alternatives B, C, and D. Since soil condition is nearly 100% in satisfactory condition, no treatments would be necessary to improve it. Therefore, implementing plan direction under all alternatives would result in maintenance of satisfactory soil condition and maintain soil productivity similarly and remain static in trend.

Alpine Tundra PNVT

Alternative A

Comparison of current, reference and projected future conditions: This PNVT has low departure from reference condition (soils are either satisfactory or satisfactory inherently unstable)for both soil condition and soil productivity with a static trend.

Projected future condition and trends: Under the current plan and applicable components, soil condition and productivity are projected to remain static. Litter, vegetation composition, and understory productivity are expected to remain about the same. The goal of attaining all areas in satisfactory condition has for the most part, already been attained.

Alternative B, C and D

From a soil condition and productivity standpoint, the identified desired conditions have for the most part, already been met. Forest-wide desired conditions stated in the beginning of this section apply. No specific plan objectives or guidelines are needed or included in the revised plan Alternatives B, C, and D to maintain soil productivity.

Trend under current plan direction of soil condition and productivity is static. Similar to Alternative A, there are no specific treatments including mechanical or prescribed fire, identified in plan direction under Alternatives B, C, and D. Since soil condition is nearly 100% in satisfactory condition, no treatments would be necessary to improve it. Therefore, implementing plan direction under all alternatives would result in maintenance of satisfactory soil condition and maintain soil productivity similarly and remain static in trend.

Comparison of Effects for Alternatives B, C, and D for all PNVTs

With respect to fire, given that frequent fire decreases fire behavior (and resultant severity), the alternatives that allow for more fire treatment acres would lead to less uncharacteristic fire behavior. Alternatives B, C, and D would generally allow for more treatment acres; however, this trend could be the opposite in key areas on the far southeast end of the forest. These alternatives would designate large areas as Semi-Primitive Non-Motorized. This designation would potentially limit mechanical and fire treatment opportunities due to restricted access. Alternatives B and D should provide the most acreage treated and a resultant lower fire intensity.

Similar to alternatives B and D, alternative C would result in more acreage treated due to fewer constraints on wildfires to meet resource objectives and a clear emphasis on fire restoration. However, alternative C would lead to less acreage treated (relative to alternatives B and D) due to the added constraints of special areas and wilderness designation. Wilderness designation constraints to fire treatment are increased logistical complexity (access limitations) and a reduction in fire management tools (e.g., chainsaws, engines, bulldozers, aviation resources). Special area designations (e.g., research natural areas, botanical areas) do not explicitly prohibit fire treatment. However, these designations result in increased complexity due to added coordination requirements and competing resource objectives. For example, research natural areas have ongoing research projects that often have specific requirements (e.g., fire, spring fire, fall fire) that can make fire treatment difficult or impractical. In addition, making necessary contacts to coordinate the use of wildfire to meet resource objectives in emergency timeframes is often impractical. Further, alternative C would likely reduce mechanical treatment opportunities; therefore, potentially limit fire treatment due to stand conditions being dense and more volatile.

Comparison of Effects for All Riparian Forest Types and Wetland/Cienega

For all riparian forest types (Montane Willow Riparian, Gallery Coniferous Riparian, Mixed Broadleaf Deciduous Riparian, and Cottonwood Riparian PNVTs) and Wetland/Cienega, Alternatives B, C, and D would include plan components that would move riparian areas toward identified desired conditions. In addition, a guideline directing identification of a vegetated streamside management zone, maintenance of 80 percent herbaceous cover and limited and

localized soil compaction and trampling of vegetation should be to the extent where permanent damage to perennial plants would not occur and result in the maintenance of soil cover, reduced sheet erosion, and improved nutrient cycling and soil productivity. The forestwide objective of restoration of 200 to 500 acres of any Non-Functional or Functional-At-Risk riparian PNVT within 10 years would treat and improve about twice as many acres as estimated in alterative A or 10 percent of total riparian areas forestwide and proportionally more per plan life of 15 years. For wetlands, the objective of restoration of 5 to 10 wetlands/10 years would improve at least 15 to 30 percent of total wetlands over 10 years and proportionally more per plan life of 15 years.

Few roads, trails and riparian areas are present and grazing would continue in the recommended wilderness areas under alternative C. Therefore, predicted soil improvement would be similar to alternatives B and D.

Implementation of plan components under alternatives B, C, and D, would indirectly cause the following scenario to occur: Riparian vegetation and protective vegetative ground cover would increase and aid in the filtering of sediments, improve soil structure, improve nutrient cycling, improve water retention and groundwater recharge and develop root masses that stabilize against cutting action associated with high water flow, thereby reducing erosion, improving water quality and maintaining soil productivity. As a result, alternatives B, C, and D would likely maintain or improve soil condition and productivity and move a large number of riparian areas to identified desired conditions more quickly than alternative A. Although implementing plan direction under alternatives B, C, and D would move soils to desired conditions faster than alternative A, movement toward desired conditions would probably still be slow based on overall small numbers of acres identified for restoration in plan objectives.

Cumulative Effects for all Alternatives

The cumulative effects analysis for this plan revision is being assessed at the 4th field HUC or subbasin scale (table 6) and are temporally bounded by the next 10 to 15 years. Disturbances that disturb vegetation, compact or detach soil can reduce soil condition, function and productivity.

Table 7 displays the 4th field HUC intersecting the forest. Influences come from within and outside of the forest boundary and cumulatively impact soil and water resources.

Past, present and reasonably foreseeable planning actions that are relevant to soil and water resources make up the cumulative effects analysis. This cumulative effects analysis does not attempt to quantify the effects of past human actions by adding up all prior planning actions on an action-by-action basis. In order to understand the contribution of past planning actions to the cumulative effects of the proposed action and alternatives, this analysis relies on current environmental conditions as a proxy for the impacts of past planning actions. This is because existing conditions reflect the aggregate impact of all prior human actions and natural events that are difficult to quantify that have affected the environment and might contribute to cumulative effects. Furthermore, existing conditions are a result of past and present impacts to soil resources. Past planning actions make up part of existing conditions and are already described in the affected environment section of this report and Alternative 1 (No Action).

The size of the subbasins and the area administered by the forest are displayed and relevant to the potential cumulative effects CNF activities may contribute to the subbasins. The percent of lands managed within the subbasins by the forest ranges from <1 – 57. Where multiple land ownership exists, it is important that the forest work with the appropriate organizations and individuals.

Table 6. Sub basins and Percent Ownership

4th Code Watershed	Percent watershed on the Forest	Percent watershed off Forest
Havasu Creek	0.2%	99.8
Middle Little Colorado River	15%	85
Canyon Diablo	57%	43
Lower Little Colorado River	15%	85
Tonto Creek	0.2%	99.8
Upper Verde River	40%	60
Lower Verde River	24%	76
Forest Totals at 4th Code Scale	**19.7%**	**80.3**

Nearly all of the management activities conducted by the forest have potential to affect soil function, condition and productivity. Their cumulative impact to a watershed depends upon the effects of past, present, reasonably foreseeable actions, and the watershed's sensitivity to disturbance.

Cumulative effects include activities on the forest as well as other public and private lands including the following:

All of the watersheds associated with the forest have private inholdings and appreciable areas outside of the forest boundary (ranges from 43-99%). Many of the impacts occur on lands of other ownership, such as unpaved roads, grazing, recreation that may result in reduced soil function, soil condition and productivity. Management activities on watersheds with high ownerships off of the forest are not in the control of the forest. These activities could cumulatively affect and are probably at greater risk of soil degradation. This would occur in private, tribal or City owned lands where land development and greater ground disturbance generally occurs compared to forest lands. These activities (listed below) could cumulatively affect Coconino forest soils, and water resources and predominate in the Upper and Lower Verde River watersheds due to current and future impacts listed below.

- Urbanization near and adjacent to the forest can contribute substantially to cumulative watershed effects. Development has the potential to affect soil resources through accelerated erosion and loss of soil productivity,. As private properties, especially inholdings, change from ranch or undeveloped land to subdivisions or higher density uses, encroachment into national Forest becomes more frequent resulting in resource impacts and decline in soil function and condition.
-
- In addition to the above potential impacts, activities on non forest lands that have a cumulative and high risk of adverse soil impacts include mining, increased trail density and use, and trampling of riparian areas.
- Entities like the Nature Conservancy and the Verde Valley Land Preservation Institute can assist in acquisition of key parcels, particularly related to riparian and the Verde River that would help maintain or improve soil conditions. The Nature Conservancy's interest in acquisition of Verde River properties and water rights may result in continued land acquisition cases depending on available funding. The interest in protecting the Verde River may become higher as Northern Arizona University works on their Verde Valley Initiatives. Support for land acquisition or other forms of protection of the Verde River and its tributaries may result in protection of soil, riparian and water resources and overall soil function, condition and productivity.
- Implementation of the preferred alternative of TMR FEIS will appreciably improve soil conditions with the closure of many roads and dispersed campsites outside riparian areas and springs. The Prescott, Kaibab and Apache-Sitgreaves National Forest are conducting similar travel management analysis and are expected to restrict motorized cross-country travel and limit and close many high risk roads that may pose a risk to soil, riparian area and water quality. These actions, should cumulatively reduce on-site erosion, and overall maintain or improve soil productivity in the aforementioned 4th Hydrologic Unit Code watersheds.
- Neighboring forests with similar forest plan efforts underway include the Prescott, Kaibab and Apache –Sitgreaves National Forests. The Coconino National forest shares portions of 4th HUC watersheds with these other forests and therefore, planning efforts directing soil resource management would indirectly impact all forests. The aforementioned forests have developed plan that would be expected to move soil resources towards identified desired conditions resulting in maintenance or improvement of soil condition and productivity.
- The following projects or planning efforts would generally result in management direction that would improves soil condition and productivity and water resources and would not contribute to negative cumulative effects.; The Four-Forest Restoration Initiative; Flagstaff Regional Plan, Verde Valley Regional Plan, Sedona community plan, national monument's management plans; Sedona and Flagstaff community fire plans, State Lands Department Plans, Rogers Lake, and Coconino County Open Space Plan. Where available, these plans have been saved at: O:\NFS\Coconino\Program\1900Planning\1920LandMgmtPlng\so\fpr-deis\03-NEPAanalysis\Interdisciplinary_References\considerations-for-cumulative-effects.

Adaptive Management

All alternatives assume the use of adaptive management principles. Forest Service decisions are made as part of an ongoing process. The land management plan identifies a monitoring program. Monitoring the results of actions will provide a flow of information that may indicate the needs to change a course of action or the land management plan. Scientific findings and the needs of society may also indicate the need to adapt resource management to new information. Soil disturbance monitoring (Page-Dumroese, et al 2010) would provide the necessary feedback for adaptive management to protect soil productivity.

Climate Change

Proposed treatments for each Alternative were evaluated for probable effects to water resources assuming these hotter, drier environmental conditions:

- Temperatures are expected to increase 0.5 degrees F per decade
- There will be more hot days with summer heat waves lasting 2 weeks or longer
- Precipitation may decrease
- Winters will be warmer with reduced snow pack and monsoon rains may start later.
- Extreme events, such as floods, may become more common.

Consequences Common to All Alternatives:

Qualitatively, climate change may result in:

- Reduced snowpack in higher elevations.
- Less water available for groundwater recharge.
- Reduced baseflows.
- Increased area where precipitation does not exceed evapotransipiration.
- Changes to stream channel morphology.

Hotter, drier environments are likely to enhance the size and severity of wildfires, and fire disturbance would increase. Larger, more frequent, high intensity fires would likely result in increased soil erosion, increased runoff, faster response to the hydrograph with higher peak flows, increased sedimentation, increased turbidity, and pulses of increased pH from ash. Severe fires can often cause changes in successional rates, alter above- and belowground species composition, generate volatilization of nutrients and ash entrainment in smoke columns, produce rapid or decreased mineralization rates, alter C : N ratios, and result in subsequent nutrient losses through accelerated erosion, leaching or denitrification. In addition, changes in soil hydrologic functioning, degradation of soil physical properties, decreases in micro- and macrofauna, and alterations in microbial populations and associated processes can occur (Neary, 1999). Soil formation and vegetation recovery is relatively slow in arid environments. The extent of loss to soil productivity would correlate to hydrologic effects. Changes to channels would likely include less vigorous riparian vegetation, reduced streambank stability, channel braiding and or

downcutting, greater turbidty, and increased stream temperatures. Baseflows could be reduced in both volume and temporally.

Management approaches that enhance ecosystem resiliency and ability to adapt during climate change include:

- Reducing anthropogenic stresses.
- Reducing uncharacteristic disturbances.
- Allowing disturbances that promote adaptation and biodiversity.

Modifying vegetation structure and composition to more open conditions allows individual plants to better compete for limited water and nutrients, and facilitates ecosystem transition from current to new conditions, such as those that result from changing natural and human disturbance regimes (Millar and others 2007).

In the long term, vegetation and fire treatment activities would be beneficial in building ecosystem resiliency and capacity for plant communities to accommodate expected changes imposed by future climate trends.

Based on current climate models, some of the climate change factors that may influence soil condition are:

- More extreme natural ecological process events, including wildfires, intense rain, flash foods, and wind events (Swetnam et al. 1997)
- Greater vulnerability to invasive species, including insects, plants, fungi, and vertebrates (Joyce et al. 2006)
- Long-term shifts in vegetation patterns (Westerling et al. 2006; Millar et al. 2007)
- Cold-tolerant vegetation moving upslope, or disappearing in some areas; migration of some plant species to the more northern portions of their existing range (Clark 1998)
- Potential decreases in overall forest productivity due to reduced precipitation (Forest Service 2008)
- Lands grazed on the Coconino National Forest are not irrigated and any variability in precipitation and temperature directly affects forage plant production and wildlife habitat. Changes in climate may affect the vigor and productivity of forage plants, and thus overall soil conditions. It is possible that higher temperatures and decreased precipitation described for the next century would decrease forage production and shorten the growing and grazing season, while flashfloods and increased risk of animal disease can adversely affect the livestock industry (Joyce et al. 2001). Soil conditions may decline if adjustments to numbers based on allowable forage are not made as productivity decreases due to climate change.

In light of the changes indicated above, there is a need to reduce vulnerability by maintaining and restoring resilient native ecosystems. Restoring and maintaining resilience is part of the basic elements of forestwide desired conditions, objectives and management approaches provided for in alternatives B, C and D. Restoring and maintaining resilience would likely improve the potential for ecosystems to retain or return to desired conditions after being influenced by climate change related impacts and variability. Management practices (e.g. thinning for age class diversity and structure, and reclaiming and restoring native grasslands) that sustain healthy plant and animal

communities, and provide adequate nutrients, soil productivity, and hydrologic function promote resilience and reduce opportunities for disturbance and damage. See Vegetation Specialist's Report for further discussion of ecological condition trends.

Consequences Unique Among Alternatives:

Alternatives B, C, and D provide the most protection to soil and water resources for expected changes imposed by predicted climate changes. This conclusion is reached based on the assessment of which alternative provides the most improvement in desired conditions Alternative A provides the least amount of ecosystem resilience and capacity for plant communities to adapt to changing climate.

Relationship of Short-Term Uses and Long-Term Productivity:

Short-term uses are those expected to occur on the Coconino National Forest over the next 10 to 15 years. These uses include, but are not limited to, recreation, grazing, mineral development, timber harvest, and prescribed burning. Although these uses are not directly implemented by the forest plan, the potential for these uses are described in forest plan desired conditions and objectives, both at the forestwide and management area levels (see chapters 2 and 3 in the forest plan) and evaluated throughout the various sections of this chapter.

Long-term productivity refers to the capability of the land to provide resource outputs beyond the life of the forest plan. Minimum management requirements prescribed by the forestwide standards and guidelines would be met under all alternatives. Minimum requirements assure that long-productivity of the land would not be impaired by short-term uses.

Unavoidable Adverse Impacts

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Before any ground-disturbing actions take place, they must be authorized in a subsequent environmental analysis. Therefore, none of the alternatives cause unavoidable adverse impacts. Mechanisms are in place to monitor and use adaptive management principles in order to help alleviate any unanticipated impacts that need to be addressed singularly or cumulatively.

Irreversible and Irretrievable Commitment of Resources

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Because the land management plan does not authorize or mandate any ground disturbing actions, none of the alternatives cause an irreversible or irretrievable commitment of resources

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