SOIL

Abstract: The primary goal of soil management on the Forests and Grassland is to maintain and where appropriate improve soil quality and health in order to sustain or improve the physical, chemical and biological functions of the soil in the ecosystem.

Management actions with the greatest potential for affecting soils are those which involve ground disturbance and vegetation removal, including vegetation management, use or development of travelways and recreation facilities, grazing, fire, and the extraction of minerals, and oil and gas. Many of the components associated with urbanization/intermix including roads, vegetation removal for housing developments, construction of playgrounds, etc., are included because of their potential impact on physical, chemical, and biological processes and functions.

Nine general map units describe soil types on the Arapaho and Roosevelt National Forests. Of the six detrimental soils impacts that can occur, and for which we have standards, compaction, displacement and erosion are of greatest concern.

Seventy-five percent of the ARNF's soils are on steep or dry areas. These areas are subject to erosion and displacement, and are the units where most Forest activities occur. Fifteen percent of the Forest's soils occur at elevations between 10,000 and 14,000 feet, where little or no activity is implemented. The vegetation is sparse and the soils are subject to erosion and mass failure. Five percent of the soils are associated with morainal features and are also subject to erosion. Three percent of the soils are associated with wetland-riparian areas and are subject to compaction and displacement; they are some of the most biologically diverse soils and have some of the greatest diversity of functions.

All three general units on the Pawnee National Grassland are subject to wind and water erosion. One unit makes up 42 percent of the PNG's soils, and is subject to compaction due in part to high clay content.

All *Forest Plan* alternatives have the potential to affect the soil resource to some degree. In general, Alternatives C, E and I have the greatest potential, Alternatives A and B a moderate potential, and Alternative H the least potential for effects, except where the potential for wildfire is increased. Fires may have intensities that could severely burn the soil.

Implementation of regional or forestwide standards and guidelines, mitigation measures, and existing laws and regulations will address the cumulative effects of past impacts and hold potential future detrimental impacts within acceptable levels. This holds for all alternatives under both "experienced" and "full" budget scenarios.

INTRODUCTION

High quality, healthy soils are a basic resource on which ecosystems and their various components including vegetation, wildlife and humans, depend for continuous growth and function. Most Forest and Grassland activities, including those authorized by permit, impact soil resources to some extent. Impacts include erosion, compaction, displacement, severe burning, nutrient removal and puddling. These impacts are not always detrimental or long lasting. In order to maintain, enhance, and, where necessary, restore the long-term quality and health of the soil, detrimental soil impacts must be maintained within tolerable limits.

The soils on the ARNF occur both in cold climatic zones on steep mountainous topography and in the milder climatic zones of the foothills. Soils range from shallow to very deep. They can contain considerable rock fragments, and are formed primarily from igneous and metamorphic rocks. The soils support a variety of alpine, subalpine, and foothill forested and meadow vegetation.

Soils on the PNG occur in a climatic zone with warm to hot summers and cold to very cold winters. The topography is typically a flat to rolling plain with some steeper and higher elevations along an escarpment. Most soils are moderately deep to very deep and are formed primarily in alluvium and residuum derived from sedimentary rocks. The soils support a variety of short grass prairie vegetation, with cottonwood trees along streams and rivers.

The soils on the ARNF-PNG have been impacted by various activities, including but not limited to mining, timber harvesting, fire suppression, grazing, recreation, urbanization and all indirect actions associated with each of these. Some activities, such as grazing, have impacted the soil since before designation as National Forest or National Grassland (U.S. Department of Agriculture, Soil Conservation Service, 1979. Soil Survey of Weld County, Colorado Northern Part). In general, activities that expose mineral soil by removing vegetation cover and litter will cause impacts.

Soil resources are linked to several of the revision topics introduced in Chapter One of this *FEIS*.

> *Revision Topic: Maintenance of Biological Diversity.* Maintaining the integrity of soil resources is a key to providing for basic, healthy ecosystem processes and functions.
>
> *Revision Topic: National Forest and Residential Intermix.* Intermix areas include highly dissected intermingled lands of mixed federal and private ownership. Development or other activities on private lands have the potential for direct and indirect impacts on the physical, chemical, and biological processes and functions of soils on adjacent federal lands.
>
> *Revision Topic: Oil and Gas Leasing.* Surface disturbance associated with the development of the subsurface mineral estate has the potential to affect the integrity of

soil resources. Decisions made on the management of leasable minerals influence soil-resource management.

Revision Topic: Recreation-Related Topics. As Front Range growth trends continue, increased demand for developed and dispersed recreation opportunities will be placed on the Forest, with implications for soil impacts, mainly in the form of compaction, erosion, and displacement.

Revision Topic: Timber-Related Topics. Conflicts between resource protection and timber production include concerns for soil processes and functions in the form of changes to soil nutrient cycling.

In addition, management of soil resources is linked to stewardship of other resources of concern in the Revision Topic forTravel Management and Other Revision Items included in Chapter One.

LEGAL FRAMEWORK

There are many statutes that reference the need to protect, and, where appropriate, improve the quality and health of the soil. Among these are:

- Bankhead Jones Farm Tenant Act of 1937 and amendments
- Sustained Yield Forest Management Act of 1944
- Multiple Use Sustained Yield Act of 1960
- Forest and Rangeland Renewable Resource Planning Act of 1974 as amended by the National Forest Management Act of 1976
- Public Rangeland Improvement Act of 1978

Direction on the technical standards for soil surveys is outlined in various handbooks and manuals (*National Soil Survey Handbook, National Soil Survey Interpretations Handbook, FSH 2509.18, FSM 2504, 2551.04, 2552.04, 2555.04* and *2556.04*). Most of the information in these handbooks and manuals is implemented through a Memorandum of Understanding (MOU), of March 28, 1991 with the Natural Resource Conservation Service (NRCS), formally known as the Soil Conservation Service (SCS). The MOU states:

> *Standard soil surveys on lands administered by the Forest Service will meet the technical standards of the National Cooperative Soil Survey (NCSS).*

NCSS is a nationwide partnership of federal, state, regional and local agencies and institutions. NCSS works together to investigate, inventory, document, classify and interpret soils data and information. NCSS also disseminates, publishes and promotes the use of information about

soils. The NRCS is responsible for the leadership of soil survey activities carried out by the U.S. Department of Agriculture, and also coordinates NCSS activities, including quality control and quality assurance.

The terms of the MOU are outlined in *FSM 1541.13.* The NCSS technical standards for soil survey are outlined in the *National Soil Survey Handbook* (1993), the draft *National Soil Survey Interpretations Handbook* (1992), and their amendments.

DESIRED FUTURE CONDITION

The desired future condition for the soil resources on the ARNF-PNG is to maintain, and, where appropriate, improve:

- the soil's ability to support and maintain vegetation cover commensurate with site capabilities
- nutrient cycle functioning and processes through decay and periodic burns
- the balance of significant nutrient drains by limiting removal of organic materials
- soil structure so that soils regulate and partition water and solute flows
- infiltration and permeability so that soils allow for plant and animal growth and movement
- functions and processes of healthy populations of soil fungi, bacteria and other soil flora and fauna

Tools such as our Regional Soil Quality Standards and water conservation practices, *Forest Plan* standards and guidelines, National Forest directives, and other federal, state and local laws and regulations will help to achieve the desired future condition. Subsequent monitoring of activities will also help in identifying existing and potential soil resource concerns.

AFFECTED ENVIRONMENT

The Forest has been conducting a progressive soil resource inventory as part of the NCSS program. As the Forest Service and NRCS have moved toward a more ecological approach to mapping and data collection, the concepts governing mapping units and intensities of surveys have changed. Part of this change was the development of the National Hierarchical Framework of Ecological Units (USDA Forest Service, October 29, 1993). See the Biological Diversity section for more detailed information.

At this time about 90 percent of the forested area has been field mapped at an Order III, with the soils classified to the soil-family level. The remaining 10 percent of the field work and indoor follow-up work was completed in September 1996. A draft soils report with ecological narratives and interpretations should be available by December 1997.

The Pawnee National Grassland has a published NRCS report complete with maps, narratives and management interpretations. Updating of the information to include the new ecological concepts of map units and survey intensities will begin as time and funds are available.

At present, the existing data have been combined into nine general map units for the ARNF and three general map units for the PNG. This information can be used at the programmatic planning level to identify areas of concern based on geology, landform, slopes, aspect and vegetation. From this information general assessments of erodibility, compaction and displacement can be made.

Data collected at the Landtype Association and lower levels can help determine the physical, chemical and biological components, processes and functions of the soil.

The ARNF's soils have been grouped into nine broad units (Table 3.2), based on climate, geology, landform and existing vegetation. This is the first step in the development of the Landtype Associations at the landscape scale. These nine units are used to analyze the effects of the revised *Forest Plan* alternatives.

Table 3.2 Arapaho and Roosevelt National Forest General Soil Map Units

Map Units	Geology	Climate	Landform	Vegetation	Percent of Forest
100	Alluvium	Lower montane, montane, and subalpine	Floodplains and terraces associated with riparian/ wetlands	Aspen, Douglas fir, subalpine fir, Engelmann spruce, willows and sedges	1
200	Alluvium	Montane and subalpine	Swales and basins. Higher elevation riparian/wetland areas	Engelmann spruce, subalpine fir, willows and sedges	2
400	Sedimentary	Lower montane and montane	Foothills and mountain slope	Aspen and sagebrush	12

Map Units	Geology	Climate	Landform	Vegetation	Percent of Forest
500	Mixed igneous, sedimentary, metamorphic	Montane and subalpine	Very steep south facing mountain slope	Ponderosa pine with kinnikinik understory	8
600	Mixed igneous, sedimentary, metamorphic	Subalpine	Lateral and ground moraines and glacial troughs	Engelmann spruce, subalpine fir, sedge grasses and willows	5
700	Igneous and metamorphic	Lower montane, montane, and subalpine	North and south facing, steep to very steep subalpine mountain slopes	Engelmann spruce, subalpine fir, lodgepole and ponderosa pine, grasses and sedges	55
800	Igneous and metamorphic	Subalpine and alpine	Alpine meadows and cirque bottoms	Engelmann spruce, grasses and sedges	13
900	Igneous and metamorphic	Alpine	Cirques	Grasses and sedges	2
Other	Mixed	Lower montane, montane, subalpine, alpine	All	Usually absent	2

The 100 and 200 units shown on the table are typically the wet areas described as riparian-wetlands. These are some of the most sensitive to disturbance and some of the most biologically diverse units.

The 400 and 500 units are dry with coarse fragments and rock outcropping. These are typically in the foothills and on very steep south facing aspects. They are not as durable as the 700s, but are generally able to recover from moderate disturbances.

The 600s are typically associated with morainal features. They are rockier, moister and deeper than the 800s or 900s. They are more durable than the 800s or 900s, but are still slow to recover.

The 700 units are the most durable with respect to disturbance. They are typically moderately deep to deep, have fair to good permeability and have moderate amounts of organic matter.

The 800s and 900s are typically found in the high elevations, have rock outcrops and little to no vegetation. They recover very slowly, if at all, from disturbance. These are also areas where few Forest activities occur.

About 2 percent of the Forest soils fall into the *other* category. This includes cirques, rock outcrops, water, rubble land, rock land, and human-created lands such as dumps. These lands typically have few or no activities implemented on them, although some may provide visual or other recreation opportunities.

Three main soil units cover the PNG (Table 3.3). A fourth unit consists of a few smaller units—less than 4 acres in size—that can be treated as inclusions. Only the three main units will be used to analyze the effects of *Forest Plan* alternatives.

Table 3.3 Pawnee National Grassland General Soil Map Units

Map Units	Olney-Ascalon-Planter series	Climate	Landform	Vegetation	Percent of Grassland[a]
	Calcarious alluvium	Warm to hot summers and cold winters	Floodplains, terraces, upland ridges and swales	Grasses (blue grama and buffalo grass), shrubs and forbs	42
Kim-Stoneham-Mitchell series	Calcarious alluvium	Warm to hot summers and cold winters	Escarpments, foot and toe slopes of alluvial and colluvial fans	Grasses (blue grama and buffalo grass) shrubs and forbs	23
Ascalon-Bushman-Curabath series	Calcarious alluvium	Warm to hot summers and cold winters	Moderately dissected plains and upland ridges	Grasses (blue grama and buffalo grass) shrubs and forbs	10
Other	Calcarious alluvium	Warm to hot summers and cold winters	All	Grasses, shrubs and forbs	25

[a] There are a few scattered cottonwood trees and willows along the streams. The soils associated with these areas are usually inclusions and make up less than one percent of a map unit.

The Olney-Ascalon-Planter units are very susceptible to wind erosion once vegetation cover is removed. Compaction when wet becomes a concern for these soils with moderate to high clay content.

The Ascalon-Bushman-Curabath units are more durable than the Olney-Ascalon-Planter units, partly because of their larger proportion of coarse fragments, which helps to maintain good permeability.

The Kim-Stoneham-Mitchell units are fine soils that are susceptible to both wind and water erosion.

In all the ARNF-PNG units, soils are generally susceptible to wind and water erosion, compaction and displacement, and may have a low potential for revegetation when the following characteristics are present:

- soils are shallow, with bedrock or other impermeable layers at 20 inches or less
- slopes are consistently 40 percent or greater
- more than 30 percent of effective ground cover has been removed
- soils are wet or saturated most of the time and the soil textures are sands, loamy sands, fine sandy loams, or clogs

Once the soil resource inventory is completed for the Forest, a report will be compiled. A vital part of soils reports is map-unit interpretation. Interpretations can:

- outline where soils may indicate existing problems with revegetation, compaction, erosion or other detrimental soil impacts
- highlight where onsite field visits should be done prior to project implementation
- highlight where soil monitoring efforts should be concentrated
- save time and money by highlighting soils of concern before projects are planned

These interpretations are one of the foundations on which soil monitoring and analyses of effects are based. They pull together scientific data and information needed to determine the limits of disturbance for a soil. The NRCS develops and defines these limits based on available research.

RESOURCE PROTECTION MEASURES

Although there are many forms of soil disturbance, five types of impacts have levels defined as detrimental because they can impact the physical, chemical and biological soil processes and functions more than other impacts. The five are compaction, displacement, erosion, puddling and severe burning (*FSH 2509.18* Ch. 2, Soil Quality Monitoring, dated 3 September 1991). The first three of these affect soils on the Forests and Grassland most. With this in mind, a minimum of 85 percent of an activity area must be maintained at a level such that the physical, chemical and

biological processes and functions are not detrimentally impacted. In other words, no more than 15 percent of an activity area may be left in a detrimentally impacted condition, exluding the permanent transportation system of roads and trails.

Mitigation measures, standards and guidelines listed in the *Forest Plan* for all alternatives, the state's "Water Quality Best Management Practices," measures in the *Watershed Conservation Practices Handbook* and other direction and guidance will be applied at the project level to protect, enhance and, where appropriate, improve the soil resource.

Table 3.4 is a general list by activity of a variety of protection measures that can be used to help maintain detrimental soil disturbances at or below acceptable levels. These mitigation measures apply to all alternatives. They are implemented on a project-specific basis.

Table 3.4 Mitigation/Protection Measures by Activity

Activity	Mitigation Measure[a]	Soil Disturbance Being Mitigated
Timber Harvesting	Designate skid trails	Compaction, erosion, puddling, displacement, nutrient cycling
	Winter harvesting	Compaction and displacement
	Scarification	Compaction, puddling, nutrient cycling
	Water barring	Erosion and displacement
	Seeding	Erosion, compaction, displacement, nutrient cycling
Grazing	Rotation of animals	Compaction, displacement, erosion, puddling, nutrient cycling
	Scarification	Compaction, puddling, nutrient cycling
	Seeding	Erosion, compaction, displacement, nutrient cycling
	Fencing	Compaction, displacement, erosion, nutrient cycling
Travelways	Contouring cuts and fills	Erosion and displacement
	Scarification	Compaction, displacement, erosion, puddling, nutrient cycling
	Seeding	Erosion, displacement, compaction, nutrient cycling
	Waterbars/rolling dips and culverts	Erosion, displacement
	Maintenance of waterbar culverts and dips	Erosion, displacement, compaction, puddling, nutrient cycling

Activity	Mitigation Measure[a]	Soil Disturbance Being Mitigated
Fire (Prescribed)	Burn at times when soil moisture is high	Severe burning, erosion and displacement
	Placement of down trees/woody material	Erosion, displacement, compaction, puddling, nutrient cycling
	Seeding	Erosion, displacement, compaction, nutrient cycling
Recreation	Waterbars/rolling dips and culverts	Erosion, displacement and compaction
	Surface hardening	Erosion and displacement
	Scarification	Compaction, puddling, nutrient cycling
	Rest/limited use	Compaction, erosion, displacement, nutrient cycling
	Seeding	Erosion, compaction, displacement, nutrient cycling
Minerals	Stockpile topsoil	Erosion and nutrient cycling
	Scarification	Compaction, puddling, nutrient cycling
	Seeding	Erosion, compaction, displacement, nutrient cycling
Oil and Gas	Stockpile topsoil	Erosion and nutrient cycling
	Scarification	Compaction, displacement, erosion, puddling, nutrient cycling
	Seeding	Erosion, displacement, nutrient cycling
	Fencing	Erosion, displacement, nutrient cycling

[a] The mitigation measures apply to all *Forest Plan* alternatives.

ENVIRONMENTAL CONSEQUENCES

Management actions with the greatest potential for affecting soils are those which involve ground disturbance or vegetation removal. These include vegetation management, travelways, recreation, grazing, fire, oil and gas, minerals and urbanization. Of the six detrimental impacts that can occur and for which we have standards, compaction, displacement and erosion are of greatest concern.

EFFECTS ON SOILS FROM VEGETATION MANAGEMENT

In general, the greater the amount of bare soil, the greater the potential for the impacts to become detrimental. When vegetation cover is removed and not replaced within an appropriate time, the potential for detrimental impacts increases. The greatest potential impact is from erosion that could occur if appropriate standards and guidelines are not implemented. Although compaction and displacement can occur, depending on the type of vegetation management, erosion remains

the primary concern, in part due to resulting changes in physical, chemical, and biological processes and functions. The amount of soil erosion occurring within a vegetation management area depends on the amount of bare soil, slope steepness, slope length, inherent erodibility, rainfall intensity, revegetation time frame, type of vegetation management activity and amount of remaining effective ground cover. Slash and logging debris reduce erosion because they protect the soil from raindrop impact and present physical barriers to soil movement. They also provide much-needed organic matter to the soils and other important nutrients and habitat for microbes.

The map units with the greatest potential for impacts are 400, 500 and 700, which make up 75 percent of Forest soils. On the Grassland all the soil map units are susceptible to wind erosion when vegetation cover has been removed.

To ensure that soils with particular limitations are protected, and that vegetation management activities occur on soils more able to tolerate these activities, site-specific and project-level reviews will be conducted.

Based on timber harvest data from the vegetation management section, Alternatives C and I have the greatest potential for impacting the soil; Alternatives E and A have a moderate,

Alternative B a slight and Alternative H the least potential for impacting the soil. This will be true for both budget levels.

Table 3.5 Potential Direct and Indirect Impacts to the Soil Resource from Vegetation Management Activities/Tools[a]

Direct Impacts	Indirect Impacts
Vegetation removal Compaction Dust Changes in microbial flora and fauna	Increased erosion Displacement Increased sedimentation Changes to aquatic flora and fauna Changes in available nutrients

[a] Implementation of project-specific mitigation measures and revised forestwide standards and guidelines will help to keep these potential impacts below detrimental levels.

Effects On Soils From Travelway Management

Travelways are associated with many activities, such as vegetation management, recreation, facilities, utility corridors and others. The building and reconstruction of roads and trails require that soil be disturbed, altered, reshaped, compacted, and/or hardened. To do this, the vegetation is typically removed. When the vegetation is removed or worn away and bare soil is exposed, there is an increased chance that detrimental disturbance, usually in the form of erosion and compaction, will take place. Compaction at or above the detrimental level will typically be necessary for travelways to meet design specifications. Areas used as roads or trails can be considered out of vegetation production because the physical, chemical and biological functions

or processes of those soils have been altered, and are not included in figures for acres of detrimental compaction.

Because travelway management involves both the removal of vegetation and ground disturbance, all three potential impacts are of concern if standards and guidelines are not implemented properly. Once the vegetation has been removed from areas with steep slopes, moderate to high mass movement potential, granitic geology and/or sandy textures, the soils begin to unravel or erode. When this process begins it can quickly spread to adjacent areas. Because these types of soils usually have low organic matter, low to high permeability, and low to moderate available nutrients, it can be difficult to reestablish effective vegetation cover. Generally these characteristics can be found in map units 400, 500 and 600. These units make up 25 percent of the ARNF and should be avoided during location and design of travelways. Travelways should also be kept out of riparian-wetland areas, mainly due to susceptibility of these areas to compaction. Riparian-wetland areas are generally associated with map units 100 and 200, and make up 3 percent of the ARNF's soils.

The Forest is proposing to close and obliterate some roads and trails. This will directly improve soil conditions on many acres by reducing erosion and compaction, and allowing vegetation to reestablish. Closure and obliteration techniques may vary from travelway to travelway, but all will help meet soil and water objectives in the long term.

Based on data from the travel management section, Alternatives C and A have the greatest potential, Alternatives E and I moderate potential, Alternative B slight, and Alternative H the lowest potential for impacting the soil. This is based on the number of proposed miles of new travelways and the number of miles of obliteration and reconstruction. This ranking would be the same for both budget levels.

Where road and travel management are carefully planned and implemented, impacts can be kept below detrimental levels, while access to the Forests and Grassland continues.

Table 3.6 Potential Direct and Indirect Impacts to the Soil Resource from Travelways[a]

Direct Impacts	Indirect Impacts
Vegetation removal Compaction Dust Changes in microbial flora and fauna	Increased erosion Displacement Increased sedimentation Changes to aquatic flora and fauna Acres out of vegetation production Changes in hydrologic patterns Changes in available nutrients

[a] If mitigation measures and standards and guidelines are implemented, these potential impacts can be kept below the detrimental level.

EFFECTS ON SOIL FROM RECREATION MANAGEMENT

In general, all recreation activities impact the soil because their implementation usually involves both vegetation removal and ground disturbance. The impact of concern will be erosion, if standards and guidelines are not properly applied. The effects on the soil and the associated map units are similar to those associated with travelways. The exceptions are those areas accessed by above-vegetation boardwalks and areas used during winter for snowmobile and crosscountry ski trails. Some research shows that there can be impacts to the soils from snowmobiles if the snow is not deep enough. These effects are mainly increases in erosion, compaction and modifications to soil microbial functions. With the amounts of snow generally present at high elevations and the limited season of use, these effects are not a concern on the Forest. Ski areas are not included in the number of acres impacted, even though they have travelways and other ground-disturbing activities. Most of the recreation activities occur in the winter, decreasing the amount of direct impacts on soil. For ski areas, measures to mitigate potential impacts and other-site specific, ground-disturbing activities are covered, in part, in the annual operating plan for the ski area. All other recreation activities are expected to have minimal effects on the soil.

It is assumed that as the population increases, specifically along the Front Range, so will the demand for use of the existing facilities and the desire for more facilities. With this comes the potential for impacts from activities occurring outside designated activity areas. Without enforcement, the potential for recreation activities to occur on soils not suitable for such activities increases.

Based on data from the recreation section, Alternatives E, C and I have the greatest potential, Alternatives A and B moderate potential and Alternative H the least potential for impacting the soil. This will hold true for both budget levels.

Where recreation is carefully planned, implemented and monitored, impacts can be kept below detrimental levels, while recreational opportunities on the ARNF-PNG continue. The potential direct and indirect impacts are the same as those outlined under travelway management.

EFFECTS ON SOILS FROM RANGE MANAGEMENT

Livestock grazing can affect the ability of the soil to support vegetation in both positive and negative ways. Livestock that are well distributed and graze grasses to an approved stubble height can maintain vegetation cover for soil protection. In addition, livestock provide needed organic matter to the soil.

The main impacts on soils associated with grazing are compaction and erosion. When grazing systems and standards and guidelines are not properly managed and implemented, upland and wetland soils may become compacted. Excessive grazing reduces or removes vegetation to the extent that soils can erode.

Although all the soils on the Grassland are susceptible to erosion if overgrazed, the Ascalon-Bushman-Curabith map units are most susceptible to resulting wind and water erosion if overgrazed. These units make up 10 percent of the Grassland soils. On the Forest the grazable areas are generally in map units 100, 200, 400, 500 and 700. Keeping animals from grazing in the riparian-wetland areas becomes important to decrease compaction and to maintain streambank stability.

Based on data from the range section, Alternatives A, B, C, E and I have the greatest potential and Alternative H the least potential for impact to soils. This is true for both budget levels and is based on the anticipated number of animal unit moths grazed.

The direct and indirect impacts of livestock grazing are the same as those associated with travelways.

Effects On Soils From Fire Management

Restoring fire to the landscape as part of ecosystem management is one of the more important actions the Forest is considering. Fire cannot be used as a tool in all ecosystems without consequences. One of the risks is the loss of biological and chemical processes and functions in the soil if fire occurs on steep slopes with highly erosive or shallow soils. This can lead to increases in erosion, compaction, displacement, and severe burning. On the other hand, fire can also provide benefits to the soil. It helps to make some nutrients more available to flora, increases the amount and diversity of the microorganisms and can stimulate vegetation growth that helps stabilize soil erosion.

Prescribed fire and wildfires can affect the physical, chemical and biological nature of the soil. The amount of soil erosion after a prescribed burn or wildfire depends in part on the inherent erodibility of the soil, intensity of the fire, amount of soil exposed, rainfall intensity, length of time the soil is exposed, slope steepness and length, amount of remaining litter and debris, and the vegetation recovery period.

Some vegetation types, such as lodgepole pine, need to burn hotter than others in order to achieve the desired ecosystem response. This increases the potential for soils to be severely burned. Conversely, in the urban/intermix area, there may be a greater emphasis on fire suppression. If suppression increases the fuel load, this may also increase the potential for severe burning of the soil. Map units with the greatest potential for severe burning are 400, 500, 600 and 700. On the Grassland all the map units have a moderate potential for severe burning.

Based on data from the fire section, Alternatives H and E have the greatest potential, Alternatives B and I have a moderate potential, and Alternatives A and C have the least potential for impacts to soil resources. As fuels build up as a result of suppression under any of the alternatives, there is a potential for the fire intensity to increase. Intense fires could burn hot enough to leave the soils in detrimentally burned condition. This can lead to detrimental levels of erosion,

compaction and displacement if standards and guidelines are not properly implemented. This would hold true for both budget levels.

Table 3.7 Potential Direct and Indirect Impacts to the Soil Resource from Fire Management[a]

Direct Impacts	Indirect Impacts
Vegetation removal Severely burned soils Dust Changes in microbial flora and fauna	Increased erosion Displacement Increased sedimentation Changes to aquatic flora and fauna Compaction Changes in available nutrients Changes in hydrologic patterns

[a] If mitigation measures and forestwide standards and guidelines are implemented, these potential impacts can be kept below the detrimental level.

Project analysis will monitor past and potential disturbance activities to assure that cumulative effects do not lead to detrimental soil conditions over greater than 15 percent of an activity area.

Effects On Soils From Minerals And Oil And Gas Management

Impacts on soil resources from mineral activities and from oil and gas management are usually in the form of erosion, compaction, displacement and contamination. Most of these impacts are short term, and last less than a year after a site has been closed down. Most impacts are mitigated through standard lease terms, stipulations, conditions of approval and operating plans.

If mitigation measures are not implemented properly, direct impacts can cause indirect impacts to terrestrial and aquatic systems. Aquatic ecosystems can be affected by water chemistry changes such as increases in sediment and toxins such as aluminum. Terrestrial ecosystems can be affected by reductions in revegetation potential due to changes in soil chemistry and biology from toxins.

Map units on the Forest with the greatest potential for impacts are 100, 200, 400, 500 and 700. On the Grassland all the map units have a moderate potential for impacts. The main soil-resource concerns are erosion and contamination if revegetation does not occur after closing a well or mine, or if an accident such as a blowout or spill were to occur.

Based on data from the oil and gas and minerals section, Alternatives C, I and A have the greatest potential, Alternatives B and E moderate and Alternative H the least potential for impacts on the soil resources. The same would hold true for both budget levels.

Table 3.8 Potential Direct and Indirect Impacts to the Soil Resource from Oil and Gas and Minerals Management

Direct Impacts	Indirect Impacts
Vegetation removal Compaction Dust Toxins	Changes in microbial flora and fauna Increased erosion Displacement Increased sedimentation Changes to aquatic flora and fauna Acres out of vegetation production Changes in available nutrients Changes in hydrologic patterns

Effects On Soils From Urbanization/Intermix

Urban areas are defined as those cities with populations of 50,000 or more. Although urban development is not taking place in the middle of the ARNF or PNG, urban areas are growing ever closer to these ecosystems. The major urbanized areas adjacent to the ARNF-PNG are Ft. Collins, Boulder, Greeley and Denver. In addition, private lands within the boundaries of the ARNF-PNG are undergoing "suburban" development.

Urbanization brings with it a variety of potential impacts to soils. While many of the direct effects, such as compaction, erosion, contamination and loss of productivity occur within urbanized areas, these effects can impact adjacent and even distant ecosystems. Paving of roads, construction of sidewalks and parking lots, and increasing the number and size of urban structures can have a dramatic effect on the microclimate, specifically temperature, by altering solar radiation processes and removing vegetation. Paving and construction also change the hydrologic processes and patterns in the area, both above and below ground. Pollutants and toxins associated with urban areas also become a concern.

Once soil has been covered with asphalt, concrete or steel, it is considered out of production as long as it is covered. Even if the human-made structures are eventually abandoned and removed and the surface has been rehabilitated, the underlying soils may continue to be affected. During construction topsoil is often mixed in or removed and clay or sand are added. When combined with the repeated pressures of heavy equipment, these changes often lead to the development of a "hard pan" impervious subsurface layer. Well developed soils with 3 to 4 inch organic layers, well developed horizonation to more than 60 inches, and a variety of soil textures and structures can be destroyed. Air, water and fauna within the soil can no longer move freely along natural channels, which can lead to significant changes in adjacent ecosystems.

Thus, a major indirect effect on ecosystems associated with urbanization is the fragmentation of soil processes and functions. As urban areas move closer to the Forests and Grassland, natural dynamics that exist between plains, foothills and mountains are altered. Processes of soils within and between ecosystems can be altered. These processes and functions include regulating and

partitioning water and solute flow, filtering, buffering, immobilizing and detoxifying organic and inorganic materials, storing and cycling nutrients, etc.

Development of intermix or of subdivisions and small towns that are entirely surrounded by and rely on access across NFS lands increases the potential for impacts to soil resources. Direct impacts such as contamination from herbicides, oils, gasoline, other petroleum products, nitrates from grazing/farm lands, erosion, and compaction will also increase as private lands are developed.

The potential for impacts from urbanization/intermix is the same for all alternatives and will hold true for both budget levels.

Table 3.9 Potential Direct and Indirect Impacts to the Soil Resource from Urbanization/Intermix[a]

Direct Impacts	Indirect Impacts
Vegetation removal Compaction Fragmentation Contamination	Changes in microbial flora and fauna Increased erosion Displacement Increased sedimentation Changes to aquatic flora and fauna Acres out of vegetation production Changes in available nutrients Changes in hydrologic patterns

[a] If project-specific mitigation measures and forestwide standards and guidelines are implemented, these potential impacts can be kept below the detrimental level.

CUMULATIVE EFFECTS

Over the next three to five decades, the potential impacts to the ARNF-PNG's soils will increase. Impacts are expected to come mainly from recreation, travelways, urbanization/ intermix, fire and vegetation management. Impacts from all other activities are expected to stay at present levels or decrease. Impacts with the greatest potential to become detrimental if mitigation measures and standards and guidelines are not implemented properly are: erosion, compaction, contamination and severe burning. Map units most at risk are 100, 200, 400, 500 and 700. As more and more people come to use the Forest, the higher-elevation 800 map units will also be prone to increased impacts. On the Grassland all the map units have a moderate potential for impact. The Olney-Ascalon-Planter units have a slightly higher potential for adverse effects because they are less rolling, have a better moisture holding capacity and are more malleable.