Forsythe II Fuels Reduction Project
Soils Specialist Report
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Existing Conditions - Geologic Setting and Climate Zones

Geology, Soil Parent Materials and Physical Processes

The geology of the Forsythe II Analysis Area (F2AA) consists of rocks igneous intrusive origin. The geologic map unit Xg (Granitic rocks of 1,700-m.y. age group) covers most of the area. Geologic map units are Tgv (Bouldery Gravels on Old Erosion Surfaces) and Xb Biotitic gneiss, schist, and migmatite. On upper hill-slopes and ridgelines, soils are formed in residual parent materials (bedrock). On lower hill-slopes and valley bottoms, soils are formed in colluvial or alluvial deposited parent materials. In the F2AA, rock weathering and soil formation is relatively slow and uplands soils are generally shallow, coarse textured and have high rock content.

In the absence of natural or anthropic disturbance, natural rates of erosion are typically low on forested F2AA hill-slopes due to high litter, duff or vegetative ground cover. Soil erosion is accelerated by ground disturbing activities or features that remove protective ground cover or alter runoff rates. Currently, most of the soil erosion in the F2AA appears to be occurring on roads and trails. Other infrequent and episodic natural erosion processes are landslides and debris flows. Hill-slopes in the area are not generally highly susceptible to mass wasting so landslides are not common. Debris flows and rock falls are far more common than landslides, particularly following wildfire.

Climate Zones and Aspect

The most of the F2AA occurs in the Lower Montane and Montane climatic zones. Small areas of sub-alpine occur as elevation increases towards the eastern part of the analysis area. North facing aspects are typically Montane while south facing aspects are Lower Montane. Within the Lower Montane and Montane, north facing slopes are generally densely forested while south facing slopes feature open forests with understory vegetation in the form of grasses and forbs. Within the F2AA, climatic zone and aspect influence the degree (severity) of project related effects, restoration success, potential wildfire effects and natural recovery of disturbed areas.

Existing Conditions - Soil Mapping, Properties and Interpretations

The F2AA is covered by 15 Ecological Land Units, most of which repeat multiple times to total 153 mapped soil polygons within the analysis area boundary. The most common upland soil order in the F2AA is Inceptisol. Typic Ustochrepts generally occur on south facing slopes and Lamellic Eutrocryepts generally occurring on north facing slopes. The central concept of the Inceptisol is minimal soil development with weak definition of soil horizons. Within the F2AA, Inceptisols are generally shallow and have high rock content and thin surface horizons. Generally, these soils are not highly susceptible to deep compaction but are sensitive to ground disturbing activities that impact protective ground cover and/or the surface layer of soil. The most common soil order within the valley bottom areas of the F2AA is the Mollisol. Typic Haplustolls and Pachic Argiborolls are mapped. The central concept of Mollisols is a thick and dark colored surface layer. These soils are susceptible to compaction and rutting. They are not highly sensitive to prescribed fire effects.

Detailed descriptions of F2AA soil properties, qualities, and limitations are available in the Soil and Terrestrial Ecological Land Unit Survey-Draft (USDA Forest Service, 2001) and through the Web Soil Survey (http://soildatamart.nrcs.usda.gov).

Summary of Soil Properties and Interpretations

For the purposes of this analysis, specific soil properties and interpretations were selected to describe project area soils and potential project related effects on soil hydrologic function and ability to support plant growth. Rates of natural re-vegetation and soil recovery following disturbance depend on many variables including type of vegetation, climatic conditions, severity of disturbance, and soil properties.

Generally, soils occurring on F2AA forested hill-slopes and ridge-tops (uplands) are shallow, rocky, have sandy loam surface textures. Additionally, most have thin surface layers and low water and nutrient holding capability. These sites are not usually highly susceptible to deep compaction but surface compaction of highly traveled areas has been observed on similar soils on other project areas. The soils have high potential for erosion if protective ground cover is removed and are particularly susceptible to loss of productivity if the organic (dark) portion of the surface layer is displaced or removed. Riparian area soils and vegetation, and/or seasonally wet soils are highly susceptible to damage caused by operation of heavy equipment or other vehicular traffic. Wet soils, steep slopes, rocky soils, and rock outcrops create moderate to severe limitations for road construction, heavy equipment operation, and other forest management activities throughout the project area.

Following soil disturbance, natural re-vegetation and recovery is a slow process in uplands soils of the F2AA. Re-vegetation is slowest where soils are shallow, sandy, rocky, and/or where soil moisture availability limits vegetative growth. Climatic variables, particularly precipitation (moisture availability) and temperature (short growing season), also limit disturbed site recovery and re-vegetation processes. Due the resilient nature of uplands soils, disturbance from forestry operations may lower soil productivity and soil hydrologic function in the near and mid-terms but is not likely to permanently impact long term site productivity provided impacts are minimized and rates of impact accumulation do not exceed rates of recovery over the long-term. Soils in valley bottoms and other wet areas are highly sensitive to disturbance because proper functioning condition of wetlands and riparian areas may be impacted if excessive ground disturbance occurs in these areas.

Specific Soil Properties and Interpretations

The following soil properties were selected to describe and interpret F2AA soils' hydrologic function, ability to support plant growth, and sensitivity to/recovery from disturbance.

Depth of Surface Layer and Depth to Restrictive Layer: Most uplands soils within the F2AA are shallow (less than 15 inches to a restrictive feature). Design criteria and mitigation measures to maintain adequate logging slash for erosion control and maintain nutrient cycling for long term soil productivity are applicable to shallow soils in the F2AA. Deeper soils are generally located in meadows and valley bottom/stream adjacent areas throughout the F2AA. Existing roads and trails in these areas create soil, watershed and fisheries resource concerns. Heavy equipment operation for the Forsythe fuels reduction project is expected to be low in these areas.

Soil Rock Content and Rock Outcrop: Over 90% of upland soils within the F2AA have greater than 35% rock fragments within the soil profile. Although this is typical of forest soils on the Boulder Ranger District, it is considered to be very high soil rock content. Generally, high soil rock content lowers the risk for deep compaction, lowers soil water holding capacity and lowers the volume of soil available for plant roots. Surface rock outcrop is dispersed throughout the project area, typically occurring along steep ridges or steep slopes adjacent to stream channels.

Wet Soils, Riparian Areas: Wet soils commonly occur in riparian areas adjacent to stream channels in valley bottoms throughout the F2AA. For protection of riparian vegetation, soil and water quality, use of heavy equipment is excluded from these areas and mitigation measures to protect soil, water quality, vegetation and riparian resources are included in project design. Mapped and unmapped wetlands, riparian areas and aquic soils should be identified in the field prior to project implementation.

Slopes, Roads and Trails, and Erosion Potential: The following analysis of hill-slope runoff and erosion potential provides a general overview of areas most sensitive to erosion within the project area. Generally, undisturbed forested areas within the F2AA are not highly susceptible to hill-slope erosion unless ground disturbance and/or removal of ground cover occurs. Roads and trails, throughout the area, ranged from relatively stable (healed over) to extremely unstable (actively eroding with snowmelt and/or rainstorm driven runoff events). Based on field observations, the road and trail network appears to be responsible for most of the soil erosion and sediment delivery to stream channels. Within the F2AA, the actual density of roads and trails on the ground is greater than road density calculated from current transportation layers or the Boulder Ranger District Motor Vehicle Use Map. From a soil and watershed hydrologic function perspective, roads and trails that are not part of the designated transportation system are considered to be connected disturbed areas. Based on field observations, erosion and sediment delivery from these areas is currently impacting soil and water resources, particularly when exacerbated by extensive off highway vehicle use.

High intensity thundershowers are the storms of highest concern for accelerating soil erosion and sediment delivery to streams. Snowmelt run-off is not likely to generate excessive erosion on treated hill-slopes. However, snowmelt run-off is likely to increase erosion of roads and trails throughout the project area.

Most of the F2AA has gentle slopes of less than 30%. By project design, heavy equipment operations for proposed vegetation management activities are limited to slopes of less than 30% to lower the risk for excessive soil erosion following treatment. Large contiguous areas of slopes of greater than 30% are generally associated with the inner gorges of the south and middle forks of Boulder Creek, lower Forsythe Canyon and lower Winiger Gulch.

Throughout most of the F2AA, hill-slope runoff potential is moderate. High runoff potential is common within steep valley inner gorges. Slope stability hazard (potential for mass wasting) is generally low with areas of moderate within the steep valley inner gorges. As expected, runoff potential and erosion/mass wasting hazard tends to increase with slope. Because of this, the preceding slope map also reflects relative differences in erosion potential. Overall, the potential for wind erosion is low for the shallow, coarse textured soils within the F2AA. However, potential for wind erosion does exist on ridgelines, particularly when exposed to the mountain peaks to the west.

Prescribed Fire Limitation Ratings: Region 2 Prescribed Fire Limitation Ratings are based primarily on slope, surface texture and effective rooting depth.

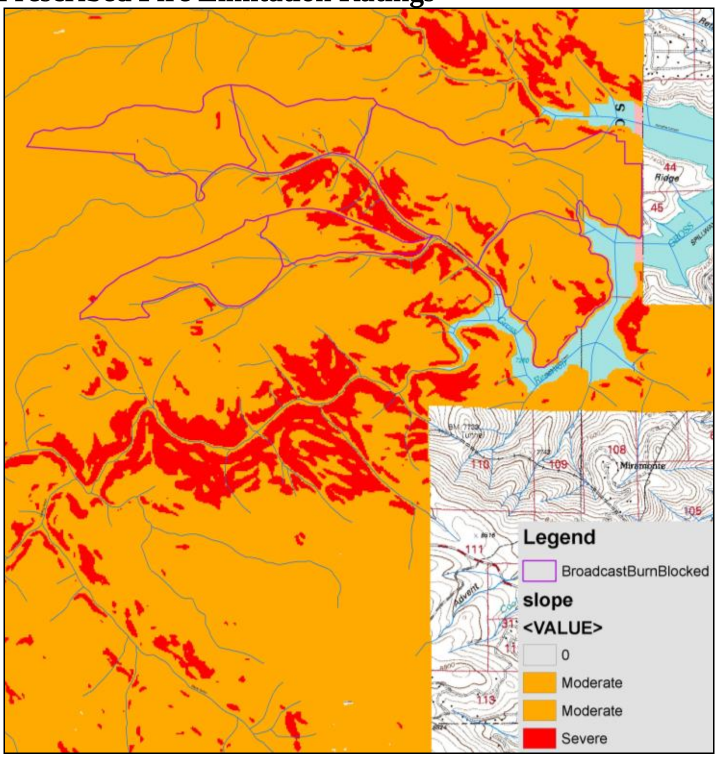
	Slight	**Moderate**	**Severe**
Slope	0-35%	35-55%	>55%

Surface Texture	Medium	Clayey	Sandy
Depth	Deep	12-36 inches	Shallow

Table adapted from R2 Soil Interpretations

Within F2AA proposed burn blocks, the predominant soil texture is sandy loam so soil texture is generally the least limiting factor for prescribed fire. Soils are typically less than 15 inches deep so depth is moderately to severely limiting for prescribed fire. Where severe limitation ratings occur, steep slopes are generally responsible. The most limiting factor determines the rating illustrated in the following map

Prescribed Fire Limitation Ratings



Generally, soils rated slight have few limitations that affect the re-establishment of vegetation and excessive erosion is not expected to result from the application of prescribed fire. Soils with moderate and severe limitations may require erosion control treatments following prescribed fire if large contiguous areas of ground cover are removed.

Condition of Soil Resources in Proposed Activity Areas

Field visits were conducted during the summer field seasons of 2011 and 2015 to determine the existing condition of soil resources in proposed activity areas. Ground cover, erosion (active or stabilized), residual compaction and displacement, depth of forest floor, surface layer, and general ground disturbance were monitored using the soil disturbance classification protocol. Data was collected by a combination of qualitative and quantitative methods. Transects, ocular observations, photographs and GPS points were collected.

Summary of Field Data Collection Efforts: Generally, ground cover was high (commonly above 90%) within proposed treatment areas and occurrences of active uplands erosion was low except for roads and other highly disturbed sites. This is because proposed treatment units are usually in areas where tree density is high, providing adequate needle-cast.

Detrimental compaction was generally limited to highly disturbed sites such as roads, trails, and other previously disturbed sites. Project area soils are not highly susceptible to deep compaction because they have sandy-loam textures and sub-soils are generally rocky.

Adequate amounts of large downed wood and slash, providing for nutrient cycling, were present in most areas. A range of decay classes of large downed wood was present but highly decomposed wood was not common. Since decomposition rates are slow and soils are not highly productive, it is important to retain fine slash and large downed logs for nutrient cycling. As a result of beetle infestation and die-off, it is likely that more large woody material and fine slash will be recruited for decomposition and nutrient cycling.

Use and Disturbance History

Past ground disturbances from fire, mining, dam/reservoir construction, timber harvest, and off highway vehicle (OHV) use exist throughout the project area in various stages of degradation or recovery.

The fire history and the activity layers from the ARNF-PNG GIS library were used to access the general use history of the area. One 75 acre burned area (1952) is located within the F2AA boundary and the Black Tiger burned area (1989) is located on the northern boundary of the analysis area. Many small fires (generally less than 1 acre) occur within and adjacent to the F2AA. Past vegetation management activities have also occurred within the F2AA boundary. The project area also has an extensive road network. From a soil and watershed hydrologic function perspective, roads that are not part of the designated transportation system (unauthorized roads) are considered to be disturbed areas. Soil productivity and hydrologic function is generally detrimentally impacted where unauthorized roads occur or where excessive runoff causes erosion adjacent to the road prism.

Desired Soil Resource Conditions

The desired condition for soils is to manage the soil resource such that the physical, chemical, and biological processes of the soil are maintained or enhanced (1997 Revised Forest Plan). Maintain long term soil productivity by limiting detrimental soil impacts within activity areas. This is achieved by application of relevant project specific design criteria, mitigation measures and watershed conservation practices (Watershed Conservation Practices Handbook, FSH 2509.25) to prevent or mitigate detrimental soil impacts.

Proposed Actions and Effects on Soil Resources

General Issues-Effects on Soil Resources

- Erosion potential
- Compaction, displacement
- Ground disturbance
- Fire effects
- Nutrient cycling and export

The type, degree (severity) and spatial extent of potential impacts are strongly correlated with implementation methods used. Proposed fuels treatment activities, methods, acreages, and associated environmental impacts to soil resources are summarized in the following table. Definitions for the potential effect "numbers" are listed directly below the summary table.

Table 1: Alternative 1 - Proposed Action. Vegetation Management Activities and Potential Effects on Soil Resources

Table 1: Alternative 1 - Proposed Action. Summary of Vegetation Management Activities and Potential Effects on Soil Resources

Prescription	Treatment Method	Slash Disposal Metho	Acres	Units Affected	Potential Effects
2-Staged Mixed Conifer Treatment	Manual	1) pile & burn 2) thin, pile, burn	**44**	74	3,5,6,7
Aspen Restoration/Conifer Removal	Mechanical/ Manual	Remove off-site, chip, masticate, pile & burn	**198**	15, 20, 32, 53, 56, 61, 62, 67, 81, 102, 106	1,2,3,4,5,6,7,8
Aspen Restoration/Conifer Removal	Manual	Remove off-site,chip,masticate,pile & burn	**33**	5, 7, 8	3,5,6,7
Meadow/Shrubland Restoration	Manual	Remove off-site,chip,masticate,pile & burn	**45**	18, 41	3,5,6,7
Mixed Conifer Treatment (Douglas Fir and Ponderosa Pine)	Mechanical/ Manual	Remove off-site, chip, masticate, pile & burn	**1354**	9, 12, 37, 39, 40, 43, 45, 46, 47, 48, 49, 50, 51, 52, 55, 57, 59, 60, 63, 68, 69, 72, 73, 77, 80, 104, 105	1,2,3,4,5,6,7,8
Mixed Conifer Treatment	Manual	pile & burn	**9**	78	3,5,6,7
Mixed Conifer Treatment OG	Mechanical/ Manual	Remove off-site,chip,masticate,pile & burn	**37**	54	1,2,3,4,5,6,7,8
Mixed Conifer Treatment OG	Manual	pile & burn	**5**	79	3,5,6,7
Lodgepole Pine Treatment	Mechanical/ Manual	Remove off-site, chip, masticate, pile & burn	**741**	1, 2, 3, 4, 10, 11, 14, 16, 17, 19, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 33, 42, 58, 75, 76, 101, 103, 107	1,2,3,4,5,6,7,8
Regeneration Thin	Manual	chip, pile & burn	**17**	82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100	3,5,6,7
Prescribed Fire - Broadcast Burning	N/A	N/A	**968**	Burn Blocks 1-6	9

Defensible Space Treatments

If property owners adjacent to NFS lands choose to do so, defensible space treatments could occur on NFS lands within 300 feet of private structures. Although acres to be treated cannot be predicted at this time, this treatment could occur over as many as 2,032 acres. Treatment method could be mechanical but is most likely to be manual. A variety of slash disposal methods could be employed. Potential effects 1 through 8 (listed below) are applicable. For protection of soil and water resources, the majority of design criteria and mitigation measures required for other USFS treatments within this project area would also be required be required on these defensible space treatment areas.

<u>Summary of Activities and Potential Effects on Soil Resources</u>
***Apply to Potential Effects Column in Table (above)**

Effects of Mechanized Treatments (Heavy Equipment Operation)

1. Moderate to severe compaction, ground disturbance, removal of ground cover, and increased potential for erosion on designated skid-trails, landings, and temporary roads. These effects are considered to be short-term because they are mitigated through restoration activities such as de-compaction, lopping and scattering slash and seeding.

2. Discontinuous ground disturbance in unit (off designated skid trails) from heavy equipment operation results in removal of ground cover and disturbance of the surface layer of soil, particularly where multiples passes or turns are made. Low to moderate compaction and increased potential for erosion commonly occurs but these areas are generally small, isolated, and discontinuous. The degree and extent of impacts are highly dependent on treatment intensity and ground conditions during the implementation period. Natural recovery of these areas occurs through re-establishment of native vegetation, needle cast and natural accumulation of woody debris over time.

Potential Effects of Manual Treatment Activities

3. There are generally few effects to soil resources associated with low intensity manual fuel reduction treatments provided adequate amounts of fine slash, litter, and duff are retained within the activity area.

Potential Effects of Slash Disposal Activities

4. Machine pile burning and piling effects
5. Hand pile burn effects
6. Chipping and masticating effects, both positive and negative, are variable based on amount, depth, and spatial extent of coverage
7. Lop and scatter effects are generally positive but variable based on amount, depth and spatial extent of coverage
8. Removal of boles (trunks) from the activity areas

Potential Effects of Broadcast Burn Activities

9. Mosaic of low and moderate soil burn severity effects (described below) with emphasis on Removal of ground cover (litter, duff and ground cover vegetation) is the primary concern. Increased erosion potential on steep and or unrecovered areas within burn polygons for 1-3 years following the fire.

Detailed Description of Activities, Effects, Design Criteria and Mitigation Measures

Potential Severe Effects on Landings and Skid-trails

Development of a network of designated skid-trails and landings is expected to occur in mechanically treated activity areas. **Detrimental compaction**, **displacement**, and **removal of ground cover**, and **increased potential for erosion** are expected to occur on skid-trails and landings where multiple passes with heavy equipment occur. Generally, a designated landing and primary skid-trail system is expected to cover between 12-25% of an activity area. These effects are considered to be short-term because they are mitigated through restoration activities such as de-compaction, lopping and scattering slash and seeding. Following restoration, full natural recovery of soil function in these areas occurs over years and decades.

Potential Minor Effects within the Unit (Off Landings and Skid-trails)

Heavy equipment (skidder, feller-buncher, harvester, masticating and chipping equipment, etc) operation off designated skid-trails is necessary to get to trees within the units. In clearcut and patchcut units where tree density and/or treatment intensity is high (large proportion of trees removed), many passes and turns may cause **minor ground disturbance** over as much as 40-50% of the activity area. Low to moderate compaction and increased potential for erosion commonly occurs but these areas are generally small, isolated and discontinuous. The degree and extent of impacts are highly dependent on treatment intensity and ground conditions during the implementation period. Natural recovery of these areas occurs through re-establishment of native, needle cast and natural accumulation of woody debris over time.

Compaction and Displacement

Soils within the activity areas are not highly susceptible to deep compaction because they are medium to coarse textured and have high rock content. However, compaction and displacement of the surface are expected to occur on temporary roads, skid-trails, landings where multiple passes with heavy equipment are made. Compaction does not always extend deep into the soil profile where soils are coarse textured and/or rocky. However, shallow compaction, increased runoff, and slower natural re-vegetation has been observed within similar activity areas. Compacted landings, temporary roads, and compacted portions of skid-trails would likely comprise less than 20% of the activity area. Compaction and/or displacement may occur in less traveled parts of the activity area if operations occur when soil is wet. Operating over a protective layer of packed snow and/or frozen ground may help prevent compaction but monitoring of similar projects indicates that it is unlikely that snow cover or frozen ground would remain over the entire implementation period, particularly on south facing slopes.

Recommendations to Prevent/Minimize Compaction

To the extent possible, operate on designated skid-trails and landings. Where possible, utilize existing temporary roads, skid-trails and landings. Operate heavy equipment only when soil moisture in the upper 6 inches is below the plastic limit (a ball can be formed in the fist that holds together on gentle tossing or shaking) OR protected by at least one foot of packed snow or 2 inches of frozen soil. This may mean temporary restrictions on equipment operation in periods of heavy rains or when soils are wet. This mitigation measure helps achieve objectives stated in watershed conservation practices 13.1 (9) and 14.1 (13) of the Watershed Conservation Practices Handbook (FSH 2509-25).

Mitigation to Treat Compaction

Use a winged sub-soiler or rock ripper shanks with winged teeth to de-compact compacted landings, temporary roads, and compacted portions of skid-trails (generally highly traveled primary skid-trails within 100 feet of landings) to minimize the accumulation of ground disturbance within the watershed and reduce project related impacts to watershed hydrologic function. This mitigation measure helps achieve objectives stated in watershed conservation practices 11.1 (5), 13.1 (9), 13.3 (11) 13.4 (12), and 14.1 (13) of the Watershed Conservation Practices Handbook (FSH 2509-25). Follow de-compaction treatment with erosion control measures such as installing water-bars, covering the area with slash, or re-vegetation as needed. This mitigation measure may be waived site specifically if on site inspection by a Soil Scientist determines de-compaction is not required.

Erosion Potential

Sustained slopes over 30% have severe erosion potential if ground cover is removed and are considered unsuitable for heavy equipment operation. Hand treatments may be implemented on steeper areas within the treatment units with minimal ground disturbance and low risk for accelerated erosion. While it is not practical to delineate small pockets of steep slopes within treatment units in the planning phase, these areas would be identified and avoided during the layout and implementation phase of the project to minimize accelerated erosion.

Erosion may occur during snowmelt or any other runoff event but storms with greatest energy and potential to cause erosion are high intensity thundershowers. Erosion potential would increase during and following project implementation due to removal or disturbance of the litter/duff layer and/or vegetative ground cover.

Following disturbance, needle cast and re-vegetation with grasses, forbs and shrubs are natural recovery processes that would occur over time to stabilize disturbed hill-slopes. However, these processes take one or more growing seasons and strategies to prevent or minimize ground disturbance within treatment areas are preferred. Wet soil operating restrictions and use of designated skid-trails (with minimal passes and turns off skid-trails) would prevent excessive removal of ground cover during and following operations. Post treatment measures such as lopping/scattering of fine slash and water-barring skid trails would also decrease the risk of soil erosion.

<u>Design Criteria and Mitigations to Minimize/Prevent Erosion</u>

- Manage land treatments to maintain enough organic ground cover in each activity area to prevent harmful increased runoff. Maintain the organic ground cover of each activity area so that pedestals, rills, and surface runoff from the activity area are not increased. Following project implementation, at least 70% effective ground cover should be maintained to lower the risk of soil erosion. Effective ground cover includes surface rock cover, pine needle cover, cover provided by low lying vegetation and mulch. These design criteria address Watershed Conservation Practice 11.2 - Management Measure (2).
- Limit ground disturbance to the minimum feasible amount and avoid soil-disturbing actions during periods of heavy rain or wet soils. Apply operating restrictions to protect soil and water. This measure reduces mobilized soil during runoff events and addresses Watershed Conservation Practice 13.1 - Management Measure (9)
- Stabilize and maintain disturbed sites during and after operations to control erosion. Provide sediment control until erosion control is permanent. Provide drainage that disperses runoff into filter strips and maintains stable fills These design criteria address Watershed Conservation Practice 13.3 - Management Measure (11)
- Reclaim disturbed sites when use ends to prevent resource damage. De-compact, re-vegetate, and close temporary and intermittent use roads and other disturbed sites within one year after vegetation management activities end. Stockpile topsoil where practicable to be used in site restoration. Use certified local native plants as practicable; avoid persistent or invasive exotic plants. Establish effective ground cover on disturbed sites to prevent accelerated on-site soil loss and sediment delivery to streams. Restore ground cover using certified native plants as practicable to meet re-vegetation objectives. Avoid persistent or invasive exotic plants. This design criteria addresses Watershed Conservation Practice 13.4 - Management Measure (12)
- Manage land treatments to limit the sum of severely burned soil and detrimentally compacted, eroded, and displaced soil to no more than 15% of any activity area to meet 14.1 - Management Measure (13).

<u>Potential Impacts on Nutrient Cycling</u>

In thinning units, the proposed activities have **low** potential to detrimentally impact long-term nutrient cycling processes because many trees would remain following treatment, providing material for recruitment of large downed wood, fine slash, or needle cast. Recruitment of material for decomposition is expected to occur naturally over time in these activity areas. The potential for nutrient cycling impacts in patch-cut or clear-cut areas is higher because more vegetative material is removed. However, provided retention of adequate amounts large downed wood and fine slash occurs, effects to long term nutrient cycling would be low.

Long-term nutrient cycling in the proposed activity areas is dependent on a continual supply of slash and large downed wood for decomposition. Project area soils are relatively sensitive to ground disturbance and other impacts to nutrient cycling because a high proportion of their productive capacity is based on the nutrient rich surface layer. Decomposition of slash and large downed wood is relatively slow due to cold winter temperatures and limited moisture availability over much of the year. The “Effects of Lopping/Scattering, Chipping, Masticating” and “Effects of Pile Burning (Burn Effects on Soils)” sections of this report provide additional analysis on disturbance processes and nutrient cycling in F2AA soils.

Design Criteria and Mitigations to Provide for Nutrient Cycling

In patchcut/clearcut areas, scatter slash and large downed logs throughout the activity area to provide material for decomposition and erosion control. Retain coarse and fine woody debris (CWD and FWD) throughout clearcut/patchcut units to maintain long term soil productivity:

- At least 8 tons/acre of CWD with preference for large diameter material (boles). Coarse woody debris is defined as material >3 inches in diameter
- At least 4 tons/acre of FWD. Fine woody debris is defined as material <3 inches in diameter

This design criteria does not compromise project fuels reduction objectives and addresses nutrient cycling objectives stated in watershed conservation practices 11.1 (5), 11.2 (6) 14.1 (13).

Ground Disturbance

It is likely that passes and turns would be made off designated skid-trail systems, causing minor ground disturbance by mixing and churning of the soil, isolated and discontinuous areas of low to moderate compaction, removal of ground cover, and increased potential for erosion commonly. The exact spatial extent of these impacts depends on size of activity area, treatment intensity, topography, soil type, equipment used, ground conditions during implementation, operator skill, and other physical constraints such as rock outcrops.

Recommendations to Minimize Ground Disturbance

Designate skid-trails and landings prior to treatment and reuse existing skid-trails as much as practicable to minimize new disturbance. Minimize passes and turns off designated skid-trails to lower the spatial extent of ground disturbance within the activity area. These mitigation measures help achieve objectives stated in watershed conservation practices 13.1 (9) and 14.1 (13).

Potential Impacts Associated with Manual Treatments

Manual treatments would be done by hand crews with chainsaws. Boles, limbs and slash would scattered or hand piled in the unit and burned at later date. With the exception of hand burn pile effects (discussed below), there would be minimal ground disturbance and adverse impacts to soil resources associated with these manual treatments. However, where ground cover or slash is sparse, it is important to scatter material to provide protective ground cover for erosion control and fine slash for nutrient cycling.

Potential Impacts Associated with Broadcast Burning

Where prescribed burning is proposed, vegetative recovery would be expected to be rapid if burn intensities are low to moderate, with erosion rates typically dropping to pre-fire levels within 2-4 years. Hydrologic recovery after fuel treatments also tends to be more rapid than after wildfire or where high severity fires occur because a smaller proportion of the forest canopy would be removed. Areas with high fuel loadings within the unit could experience higher soil burn severity, which could increase the potential for erosion and runoff. Additionally, high soil burn severity areas would take longer to recover following the burn. Due to steep slopes and increased risk for soil erosion following the burns, it is likely some sedimentation of Winiger Gulch and/or Gross Reservoir would occur in response to high intensity thundershowers within 1-4 years following the burn[1].

The following analysis of fire effects at the burn block scale is based on controlled burning within the prescription outlined in the project burn plan. Under these conditions, the expected effect is a mosaic of low and moderate soil burn severity effects.

Burn Block 1: Burn Block 1 is 340 acres and drains to Wineger Gulch less than half a mile from Gross Reservoir. This burn block is characterized by grass and conifer stands of varying densities in the south-western part of the burn block. Soil burn severity is expected to be low over the grass dominated area and recovery of slope stability is likely to be rapid (1-2 years) provided adequate soil moisture is available to support re-growth of the grass. In the conifer stands of the south-western part of the burn block, ground cover is provided by pine needle litter, duff, grass/forbs and rock. Prescribed fire would likely char but not completely consume protective ground cover, resulting in a mosaic of low and moderate soil burn severity. Recovery of pre-fire erosion and runoff rates is likely to occur within 2-4 years through needle cast and establishment of grass and forbs. Prescribed fire in this forested, south-western part of the burn block has moderate to high potential to increase soil erosion and sediment delivery potential to Winger Gulch, particularly during the first thundershower season following the fire.

Burn Block 2: Burn Block 2 is 168 acres. This burn block is characterized by denser stands on steep terrain directly adjacent to Gross Reservoir. In this block, ground cover is provided by pine needle litter, duff, grass/forbs and rock. Prescribed fire would likely char but not consume protective ground cover, resulting in a mosaic of low and moderate soil burn severity. Recovery of pre-fire erosion and runoff rates is likely to occur within 2-4 years through needle cast and establishment of grass and forbs. Overall, prescribed fire in this block has moderate to high potential to result in increased rates of soil erosion and sediment delivery to Gross Reservoir, particularly during the first thundershower season following the fire.

Burn Block 3: Burn Block 3 is 114 acres and drains to Wineger Gulch less than 1mile from Gross Reservoir. This burn block is characterized by grass with a small stand of trees near the western perimeter. Soil burn severity is expected to be low over the grass dominated area and recovery of slope stability is likely to be rapid (1-2 years) provided adequate soil moisture is available to support re-growth of the grass. A small stand of trees occurs near the western perimeter of the burn polygon. In this stand, ground cover is provided by pine needle litter, duff, grass/forbs and rock. Prescribed fire would likely char but not completely consume protective ground cover, resulting in a mosaic of low and moderate soil burn severity. Recovery of pre-fire erosion and runoff rates is likely to occur within 2-4 years through needle cast and establishment of grass and forbs. Overall, prescribed fire in this block has low potential to adversely affect soil and water resources.

Burn Block 4: Burn Block 4 is 146 acres and drains to Wineger Gulch less than 1.5 miles from Gross Reservoir. This burn block is characterized by grass with a stand of trees in an ephemeral swale, tributary to Wineger Gulch. Soil burn severity is expected to be low over the grass dominated area and recovery of slope stability is likely to be rapid (1-2 years) provided adequate soil moisture is available to support re-growth of the grass. A small stand of trees occurs near the western perimeter of the burn polygon. In the conifer stand, ground cover is provided by pine needle litter, duff, grass/forbs and rock. Prescribed fire would likely char but not completely consume protective ground cover, resulting in a mosaic of low and moderate soil burn severity. Recovery of pre-fire erosion and runoff rates is likely to occur within 2-4 years through needle cast and establishment of grass and forbs. Prescribed fire in this part of the burn block has moderate to high potential to increase soil erosion and sediment delivery to Winger Gulch, particularly during the first thundershower season following the fire.

Burn Block 5: Burn Block 5 is 72 acres and drains to the South Fork of Wineger Gulch, less than half a mile from Gross Reservoir. This burn block is characterized by open conifer stands on steep terrain. In this stand, ground cover is provided by pine needle litter, duff, grass/forbs and rock. Prescribed fire would likely char but not completely consume protective ground cover, resulting in a mosaic of low and moderate soil burn severity. Recovery of pre-fire erosion and runoff rates is likely to occur within 2-4 years through needle cast and establishment of grass and forbs. Prescribed fire in this part of the burn block has moderate to high potential to increase soil erosion and sediment delivery to Winger Gulch, particularly during the first thundershower season following the fire.

Burn Block 6: Burn Block 6 is 127 acres and drains to the South Fork of Wineger Gulch, less than 1 mile from Gross Reservoir. This burn block is characterized by moderately dense conifer stands. In this stand, ground cover is provided by pine needle litter, duff, grass/forbs and rock. Prescribed fire would likely char but not completely consume protective ground cover, resulting in a mosaic of low and moderate soil burn severity. Recovery of slope pre-fire erosion and runoff rates is likely to occur within 2-4 years through needle cast and establishment of grass and forbs. Prescribed fire in this part of the burn block has moderate potential to increase soil erosion and sediment delivery to Winger Gulch, particularly during the first thundershower season following the fire.

Design Criteria and Mitigations to Minimize Broadcast Burn Effects

- Limit total unrecovered burned area within the project area to no more than 340 acres
- Design and implement prescribed fire for low soil burn severity effects and rapid recovery[1] of ground cover. Soil burn severity classes are defined in the Field Guide for Mapping Soil Burn Severity (http://www.fs.fed.us/rm/pubs/rmrs_gtr243.pdf).
- Rehabilitate constructed fire lines by installing water bars, raking topsoil back over the line, covering with slash or other mulch materials; and seeding, if recommended by a U.S. Forest Service Botanist.
- Buffer stream channels and limit activities with buffers as described in the Forsythe II Hydrology and Fisheries Report.
- Conduct burning operations so that no more than 10% of either stream bank area within riparian zones burns with high intensity (i.e. top kill of willow and/or aspen). Actively suppress fire if this 10% threshold is exceeded.
- No active ignition shall occur within 25 feet of ephemeral streams.

Potential Impacts Associated with Using Heavy Equipment to Construct Burn Piles

In mechanically harvested units, burn piles would be located in the unit or on the landings. Operation of machinery to construct piles would likely cause ground disturbance, compaction, and removal or mixing of surface layer due to many passes and turns near piles. Machinery that lifts and places material into piles (such as a grapple piler) would minimize soil disturbance at

[1]**An unrecovered burn is one that has insufficient ground cover to reduce erosion rates to pre-burn conditions.** Typical time to recovery is 2-4 years, but is highly variable with vegetation type and precipitation. Grass, whose roots are left intact following fire, may recover in one growing season. Lodgepole pine, that often lacks an understory, usually takes longer to recover, because grass/forb/shrub seeds need to be transported in from outside the burned area. Extended draught can lengthen the recovery before vegetation will be established. The typically lower fire severity of prescribed fire may shorten recovery times. Research along the Front Range indicates that ground cover of 60%-80% typically will reduce erosion and sediment to background levels.

pile locations. Machinery that pushes material into piles (such as a bulldozer or skidder with a blade) is likely to result in severe ground disturbance. Machinery that drags material into piles (such as skidder with a grapple hook) is likely to result in moderate ground disturbance.

Burn Pile Sizes and Spatial Extent (footprint) of Piles within Units

The exact spatial extent (cumulative footprint) of burn piles depends on the amount of material cut, amount of material disposed of by other methods, pile height, density and shape.

Generally, large machine built piles are not likely to exceed 20 feet in either direction. Piles are constructed by hand and are typically less than 10 feet in diameter. On a per acres basis, creating one large machine pile impacts less ground (area) than several short/small piles. The total spatial footprint of large machine built burn piles constructed from material removed from an intensively treated densely forested acre would likely cover less than 3% of that acre. If the same acre was treated manually, the total spatial footprint of the smaller piles could be potentially cover as much as 15% of that acre.

The larger piles are expected to generate more heat, burn longer and generate more severe burn effects than smaller piles. For the purposes of this analysis, it is expected that, regardless of pile size or soil type, burning machine piles with heavy fuels is most likely to create a high burn severity impact (see burn severity definitions in glossary) due to heat and residence time of the fire. Although burning hand piles is expected to result in lower burn severity and recovery times are expected to be faster, it is expected that the physical, chemical and biological fire effects, outlined below, would occur to the extent of the machine and hand burn pile sites.

Potential Effects of Broadcast and Pile Burning (Fire Effects on Soils)

Adverse fire effects on soils are proportional to the residence time of the fire and the amount of heat generated. Generally broadcast burning results in a mosaic of low and moderate soil burn severity effects. Due to longer residence time of fire, burning piles generally results in high to moderate soil burn severity effects.

Physical Effects	• Loss of litter layer, soil and soil organic matter • Loss of soil structure • Hydrophobicity (formation of water repellent layer) • In extreme cases, destruction of clay minerals
Biological Effects	• Direct mortality of soil organisms and loss of their habitat • Fire may sterilize soils although natural recovery is expected to occur over time • Post fire changes in soil organism populations are invertebrate and fungi decrease and bacteria increase. These changes generally last a year or two.
Chemical Effects	• Increase in pH • Loss of cation exchange capacity • Loss of nutrients by volatilization, in fly ash, or by leaching

Recommendations to Minimize Burn Pile Effects

- To the extent practicable, construct machine slash piles on landings. If machine piling is done off landings, conduct piling to leave topsoil in place and to avoid displacement of topsoil. Machinery that lifts and places material into burn piles is recommended over machinery that pushes or drags material into burn piles.
- Hand constructed burn piles shall be located at least 50 feet from perennial streams, wetlands, fens, wet meadows, and aspen stands. For intermittent and ephemeral streams,

burn piles shall be located 50 feet from the stream or outside the inner gorge, whichever is less. For Preble's meadow jumping mouse, piles shall be located at least 100 feet from the edge of the water around Winiger Gulch and the unnamed southern tributary to Winiger Gulch. If it not practicable to locate piles sufficiently away from streams, or if doing so would violate other requirements (e.g. minimum spacing between piles, minimum distance from residual trees), do not cut the water adjacent trees, unless approved by a U.S. Forest Service Soil Scientist, Hydrologist, or Fish Biologist.

- To minimize long-term effects of pile burning, watershed, botany and/or implementation personnel would conduct surveys to identify if and where burn pile restoration actions are needed following pile burning activities. Any combination of the following restoration actions would be recommended if/where needed:
    - Tilling/scarifying after burning to promote recovery by breaking up water repellent layers, increasing water infiltration, and mixing in organic material from areas adjacent to the pile.
    - Weed treatments
    - Seeding
    - Covering with litter, duff and/or slash

Implementation of these recommendations would help achieve objectives stated in watershed conservation practices 13.1 (9) and 14.1 (13) of the Watershed Conservation Practices Handbook (FSH 2509-25).

Effects of Slash Treatment by Lopping/Scattering, Chipping and Masticating

In mechanically treated units, slash disposal and removal of material would be accomplished by one or more of the following methods: lopping and scattering, chipping, masticating, hand piling and burning, machine piling and burning, or skidding and removing. In manually treated units, slash disposal would be accomplished by lopping and scattering and/or hand piling and burning and/or chipping.

The effects of these slash disposal activities on soil resources could be beneficial or harmful, depending on the amount, size, and spatial distribution of material retained.

Potential Positive and Negative Effects on Soil Processes/Functions are:

- Erosion Control - Retention of slash/chips/chunks may benefit soil resources by providing protective ground cover.
- Soil Nutrient status - Microbes decomposing this wood (chips and chunks) could immobilize nitrogen and reduce soil nutrient availability to a small degree. When the wood becomes mostly decomposed, it would begin to release nitrogen and increase soil nutrient availability.
- Soil carbon – Slight increase in soil carbon over time
- Soil physical properties – Increased soil moisture retention and decreased diurnal and seasonal soil temperature fluctuations. Heavy equipment used for chipping or mastication may compact the soil.
- Soil biota - Woody debris provides habitat for soil insects and microbes and addition of carbon from woody debris will lead to an increase in soil biota, especially fungal species that are the primary wood decomposers.
- Fire risk or behavior – Under certain conditions, slash and chipped/masticated materials may smolder, resulting in a longer residence of fire at the soil surface

Mitigations to Address Potential Effects of Slash Disposal Activities

In chipped areas, chip depth shall average less than 3 inches. Chip depth of up to 5 inches may occur over small areas (not to exceed 5% of the treatment unit). Chips shall be distributed in a mosaic pattern over no more than 30% of the activity area.

Indirect Effects of Fuels Reduction Treatments

Reduced or Increased Potential for Adverse High Severity Wildfire Effects
The proposed treatments may lower the potential for wildfire spread on the landscape and lower wildfire effects within treatment units.

At both watershed and treatment unit scales, the proposed treatments may indirectly **lower** adverse wildfire effects, listed below, on F2AA soil resources.

- Removal of large areas of protective ground cover, reduction of needle cast potential, and increase in post wildfire erosion risk
- Consumption of litter, duff, large downed woody material and volatilization of soil humus and associated plant available nutrients
- Formation of hydrophobic soil conditions
- Potential for debris flows
- Other fire effects on soils described in the pile burning section of this report

Increased Potential for Access by Recreational Forest Users
Following implementation of the proposed fuels reduction activities, forest access would likely remain at current levels or increase in treated areas, which may lead to additional ground disturbance, erosion, and sedimentation.

Increased Potential for Introduction of Noxious Weeds
Following project implementation, there is a higher potential for introduction or spread of noxious weeds on highly disturbed sites such as skid-trails, landings and burn piles. Implementation of mitigation measures and design criteria to minimize ground disturbance would lower the degree and extent of impacts to soil resources and reduce the potential for introduction and establishment of noxious weeds.

Direct and Indirect Effects of Proposed Road Actions

Road Actions

- Construct, use and restore approximately 6.7 miles of temporary roads to access treatment units
- Decommission identified National Forest Systems Roads (approximately 6.4 miles)
- Decommission any unauthorized roads on NFS lands not identified on the map
- Convert 2.3 miles to administrative use only
- Add Wildewood Trail (0.36 miles) and/or Doe Trail (0.72 miles) to the national forest road system to provide emergency egress for Big Springs Subdivision.

Road Related Effects on Soil and Watershed Resources

System Roads: Road use and improvement of current system roads would have variable effects on soil and watershed resources. The current use, condition, and stability of any particular road would determine impacts associated with maintenance, repairs and/or increased use as follows:

- Using, repairing or maintaining roads for project implementation could generate additional minor short-term road surface erosion and sediment production. Soil erosion from the road surfaces and sedimentation would be limited by effective road drainage and other best management practices.
- Maintaining and using roads that are currently lightly used or unused, well vegetated, and stable would generate additional watershed impacts
- If the road is heavily used, poorly maintained and/or unstable, maintenance actions may benefit watershed functions by reducing excessive erosion of the road surface
- Decommissioning/restoration of approximately 6.4 or more miles of roads would benefit soil and water resources
- Converting 1.08 miles of trail to egress roads would generate additional ground disturbance. Soil erosion from the road surfaces and sedimentation could occur but would be limited by effective road drainage and other best management practices.

Temporary Roads: Creating and using approximately 6.7 miles of temporary roads would create additional soil displacement and compaction within the watershed. These roads would be decommissioned and restored following vegetation management treatments. Over construction and use period, erosion from these road surfaces could occur in response to snowmelt and thundershower precipitation/runoff events but would be limited by effective road drainage and other best management practices. Obliteration/restoration of these areas would involve re-contouring and de-compacting to accelerate recovery of hydrologic function and vegetation. Implementation and effectiveness monitoring of the obliteration/restoration work is recommended to determine if closures, erosion control and re-vegetation efforts were implemented as planned, effective and to determine if repair and/or maintenance needs.

Unauthorized Use and Expansion of Road/Trail Network: The proposed road actions may provide opportunity for increased unauthorized use of the area by increasing access, potentially resulting in additional ground disturbance and watershed impacts. However, road decommissioning actions following fuels treatments would likely moderate the amount of increased unauthorized use and associated effects on watershed resources.

Direct Effects of No Action

Mechanical, hand, or combination fuel reduction treatments would be not implemented. Project related ground disturbance and direct effects to soil resources would not occur and natural recovery of previously impacted areas would continue. Litter, slash, and large downed woody material would continue to accumulate and decompose at natural rates. In areas affected by mountain pine beetle, above normal rates of accumulation of litter, slash, and large downed woody material would occur. This would not adversely affect soil function but could alter nutrient cycling processes and water retention capability in the near-term and mid-term, particularly carbon and nitrogen cycling.

Proposed road actions and associated positive and negative effects would not occur. The existing road and OHV trail network would remain on the landscape. OHV activity would likely remain at current levels or increase, which would lead to additional erosion, compaction, and sedimentation.

Indirect Effects of No Action

Reduced potential for the adverse high severity wildfire effects as described in the indirect effects of fuels reduction treatments section of this report.

Comparison of Alternatives

Comparison of Alternatives: Direct Effects

The following comparison of direct effects on soil resources is based primarily on treatment method and acres treated. Other factors considered include site sensitivity to disturbance, notable differences in treatment intensity (used as an indicator for relative differences in heavy equipment passes/turns) and slash generated.

Generally, ground disturbance and associated effects on soil resources are expected to be highest in the patch cut/clear cut treatment units because these more intensive treatments require more passes and turns with harvesting equipment. Thinning activities in the mechanically treated mixed conifer units are expected to be less intensive than the patch cut units and, therefore, have fewer effects on soil resources. Of the mechanically treated units, the lowest rates of ground disturbance are expected to occur in the Aspen restoration units. No mechanical treatments will occur within the meadow restoration treatment units.

Comparison of Alternatives

The following comparison of alternatives is based on issues/effects and indicators analyzed for this project.

In the lodgepole pine (clear cut/patch cut) treatment areas, Alternative 1 – Proposed Action would cause the most effects based on the highest acreage treated. With 445 acres treated, Alternative 4 would generate the 2nd highest effects within patch cut units. The spatial extent of effects associated with Alternatives 2 and 3 are similar but clear cut/patch cut acres on sensitive soils were reduced for Alternative 3.

In mechanically treated units with prescriptions other than clear cutting/patch cutting, Alternatives 1 – Proposed Action, 3, 2 would impact 1589, 1480 and 1237 acres respectively. Effects would be similar. Alternative 4 would not generate any heavy equipment operation effects but the spatial footprint of burn piles would be higher.

In clear cuts/patch cuts, impacts on above and below ground nutrient cycling process are influenced by retention and/or potential future recruitment of coarse and fine woody debris, disturbance of surface layers and soil properties. Retention of woody material is of primary concern in patch cut units because potential for future recruitment is limited.

Overall, implementation Alternative 1 – Proposed Action would cause the most direct effects on soil resources due to the highest acreage treated mechanically. The extent and degree of potential effects associated with Alternative 2 is similar to Alternative 3. Implementation of Alternative 4 would generate the fewest effects of all the action alternatives overall.

Effects of slash disposal activities are described in detail on pages 16-19 of the soils report. The footprint and spatial extent of machine built burn pile effects mirrors the acreage and/or intensity of mechanical treatments described in the preceding paragraph. Implementation of Alternative 4 would likely generate fewer machine built burn pile effects but more hand built burn pile effects. The following comparison of direct effects on soil resources is based primarily on treatment method and acres treated. Other factors considered include site sensitivity to disturbance, notable differences in treatment intensity (used as an indicator for relative differences in heavy equipment passes/turns) and slash generated.

Potential future indirect effects on soil resources are based primarily on future wildfire severity and size. In the event of a future wildfire, treated areas are likely to experience lower soil burn severity effects where consumption of ground cover and surface fuels is lower. If proposed treatments lower the size of a future wildfire, the spatial extent of detrimental effects to soil resources, particularly accelerated rates of erosion, would likely be lower. Based on these assumptions and discussion with the project Fire and Fuels Specialist Alternatives 1 – Proposed Action and would likely be the most effective in reducing adverse future wildfire effects on soil and water resources. Alternatives 2 and 3 would be less effective based on lower treatment intensity and Alternative 4 would be least effective based on absence of patch cuts and clear cuts.

Cumulative Effects

Past measurable detrimental impacts to soils, associated with wild fires, timber harvest dispersed camping, roads and OHV use and residential development, still exist on the landscape. Potential direct effects on soil resources associated with project implementation, as described in this report, are erosion, compaction, and impacts to nutrient cycling. Areas that were compacted or eroded are in various stages of recovery. Based on field reconnaissance, review of aerial photography and limited management activities within the past 30 years, the extent of past detrimental impacts is estimated to be low for project activity areas. Through prevention or mitigation, the sum of past (existing) impacts and project related direct effects would be kept within 15% of any given activity area FSH 2509.18 and FSH 2509.25).

At the analysis area and/or watershed scale, cumulative effects include historic and ongoing activities as well as future activities. The primary activities that contribute to watershed and aquatic cumulative effects include water diversions, roads and residential/commercial development on private lands. Road densities are high in all of the watersheds, and are a primary source of anthropogenic sediment into streams and waterbodies. Development on private land can serve as an additional source of sediment as well as a potential source of other pollutants.

Except for continually used road surfaces, other disturbed soil within project area watersheds is naturally recovering from past management activities. Generally, project area soils exhibit proper hydrologic functioning condition and ability to support plant growth. Eroding road surfaces continue to deposit fine sediment into Winiger Gulch and Forsythe Creek.

Monitoring

Implementation and effectiveness monitoring is recommended. Monitoring should be conducted by ARF Watershed Personnel and other key personnel from the Planning and Implementation Team. Specific monitoring items include:

- Mechanical Treatments: Slash retention for nutrient cycling and erosion control, de-compaction, erosion control and re-vegetation of severely impacted landings, skid trails and temporary road, burn pile effects and recovery
- Manual Treatments: Burn pile effects and recovery

- Broadcast Burn Treatments: Soil burn severity and post treatment erosion

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Glossary

- Activity Area: An area of land impacted by a management activity or activities. It can range from a few acres to an entire watershed depending on the type of monitoring being conducted. It is commonly a fuels reduction cutting unit. However a unit may be divided into more than one activity area if the activities within the unit create a different level of impacts. For example, a Soil Monitor would consider a patch cut site and a thinning site separate activity areas.
- Burn Severity: Burn severity indicates the impact of fire on soil resources. Severe burns kill soil biota, alter soil structure, consume litter and humus, and remove organic matter and nutrients (FSH 2509.18). Severe burns are expected at burn pile sites. High intensity wildfire may also result in areas of high burn severity. Prescribed fire generally results in low burn severity. Complete descriptions of burn severity are found in the Burned Area Emergency Rehabilitation Handbook (FSH 2509.13)
- Cation Exchange Capacity: The sum total of exchangeable cations a soil can adsorb. Associated with the clay and humus fractions of the soil and highly correlated with plant nutrition
- Compaction: Reduction of soil porosity or increase in soil bulk density
- Detrimental Soil Impacts: Activity area (unit) soils are considered detrimentally impacted when the extent detrimental of compaction, displacement, puddling, severe burning or erosion exceeds 15% of the area. USDA Forest Service soil quality standards are meant as early warning thresholds of detrimental soil conditions. Detrimental soil conditions result in a true productivity decline and need to be as great as 15 percent to be detectable by current monitoring methods. Therefore, threshold soil quality monitoring standards are set at the level of soil change corresponding to a statistically detectable, 15 percent, decline in potential productivity; this does not imply that absolute productivity of a site has declined 15 percent, but that a detrimental soil condition threshold has been crossed (Powers, et. al., 1998). This activity area standard is mostly applied to soil porosity and bulk density as a measure of compaction, but has also been used as a measure of organic matter loss. Changes of greater than 15 percent increase in bulk density; removal of topsoil from a continuous area greater than 100 feet square; accelerated erosion evidenced by pedestalled rocks or plants, erosion pavements, or rills greater than 1 inch deep; and severely burned soil evidenced by consumption of organic matter to bare mineral soil, reddened surfaces and charred roots in upper cm of soil are all considered to be detrimental soil disturbance as defined by Region 2 Soil Quality Standards (FSH 2509.18-92-1), (Powers, et. al., 1998).
- Detrimental Compaction: A 15% increase in bulk density from undisturbed bulk density
- Detrimental Displacement: The removal of soil from a continuous area of 100 square feet or more
- Detrimental Erosion: Any indication of sheet erosion. Any rills or gullies greater than 1 inch deep
- Detrimental Puddling: Puddling occurs when soils are compacted when saturated. Compaction is used to monitor detrimental puddling
- Erosion Hazard Rating: A measure of the susceptibility of a soil to erosion based on soil properties and slope. Effective ground cover also controls potential for erosion
- Humus: Fully decomposed (composted) soil organic material
- Hydrophobicity: Formation of water repellent layer in the soil following combustion of plant materials

- Loamy Skeletal: Soils contain more than 35% rock fragments
- Long-term Site Productivity: Soil productivity depends on soil structure, organic matter, nutrient pools and biotic processes. Long-term site productivity is altered when disturbance processes exceed recovery processes over time.
- Most Limiting Value: There are usually 2 or 3 soil types within each soil-mapping unit. Often, one of the soil types is more limiting than the others for any proposed management activity (road building, erosion hazard rating, etc)
- Soil Moisture Regime: An indication of the time period a soil is dry, moist or saturated
- Soil Structure: the arrangement of soil particles into peds. Structure is generally broken down when compaction occurs

Soil Texture: Relative proportions of sand, silt and clay in soil. Coarse textures are associated with “sandy” soils and fine textures are associated with “clay” soils