3.8 SOIL

Affected Environment

Introduction

This section will discuss key assumptions and methodologies used in the analysis; describe desired conditions and site-specific resource conditions; discuss resource impacts and effects of the proposed action and alternatives; and identify specifically required disclosures for soil resources.

Assumptions and Methodologies of Analysis

Key Assumptions and Methodologies – The analysis method is to present the desired conditions for soil resources; describe soil types and conditions within the project area; present information on potential effects of the treatments; and then present recommended mitigation measures.

Existing Inventories, Monitoring, and Research Literature Review – Several sources of information are used to determine the current quality and condition of soil resources and to analyze the effects of the proposed project and alternatives. Information on the distribution and properties of soil types within the analysis area can be found in the Soil Survey of Rich County, Utah (USDA NRCS 1982). Several interdisciplinary field trips were taken to the project area in July and August of 2006 to confirm the accuracy of the soil survey data, to review watershed conditions in the areas proposed for vegetation treatments as well as areas treated previously with timber harvest activities, and to determine the effects of past timber treatment activities in the area and soil and water conservation measures that were implemented to reduce erosion and sedimentation. A comprehensive listing of field trips to the area to collect information and examine aspects of the proposal can be found on page 1 of the Soil Monitoring and Assessment Field Plots Report (Flood 2006b).

Results of Analysis

Desired Conditions

Forestwide Desired Conditions (Soil, Water, Riparian, and Aquatic Resources) – Most soils have at least minimal protective ground cover, soil organic matter, and coarse woody material. Soils have adequate physical properties for vegetative growth and soil-hydrologic function. Physical, chemical, and biological processes in most soils function similarly to soils that have not been harmfully disturbed. Degradation of soil quality and loss of soil productivity is prevented. Soil-hydrologic function and productivity in riparian areas is protected, preserving the ability to serve as a filter for good water quality and regulation of nutrient cycling. Soil productivity, quality, and function are restored where adversely impaired and contributing to an overall decline in watershed condition. (USDA Forest Service 2003, p. 4-6)

Bear Management Area Desired Conditions – Given the scarcity of perennial streams in this semi-arid area and their high value for wildlife, fish and aesthetics, all uses will be managed with specific attention to maintaining or enhancing the integrity of stream, spring, and riparian environments. Watersheds will be properly functioning with adequate ground cover to prevent soil erosion, and provide infiltration and moisture holding for storage and release of water to streams and aquifers. Spring sources and associated bogs and wetlands will be protected from excessive use and have been restored to proper functioning. Riparian areas will be properly functioning with adequate deep-rooted vegetation or armoring along banks to allow for sediment filtering and erosion prevention. Riparian areas will be protected from overuse and trampling from livestock grazing and recreation uses. (USDA Forest Service 2003, p. 4-120)

Soil Resource Features and Conditions

The analysis area is located on the east side of the Bear River Mountains and the waters of this area drain into Bear Lake. The elevation range for the analysis area is from 8,900 feet at Red Spur to 6,400 feet at Randolph.

The geology is described in the Revised Forest Plan and is presented again as a summary description of the geology of the analysis area (USDA Forest Service 2003). The area has gently sloping, eastward tilting uplands and the structure is a plateau-like surface of uplifted portions of overthrust fault zone and the lithology is Wasatch limestone, dolomite and quartzite with Cambrian rocks (Tintic quartzite, Maxfield limestone) on the west side. Geomorphic processes are fluvial and glacial; peri-glacial features are widespread. Slopes are mostly steep to very steep with some slightly steep slopes on the alluvial fans along the foothills.

Information about the type of soils that occur within the analysis area can be found in the Soil Survey Report for Rich County (USDA NRCS 1982). Table 3.8.1 contains a summary of pertinent soil characteristics from this survey.

Table 3.8.1. Big Creek Analysis Area soil types and properties for treatment units proposed under the action alternatives.

Soil Type/ Component	Slope* (%)	Texture*	Rock* (%)	Depth* (inches)	T Factor**	Compaction Potential ***	Severe Burning Hazard ***
AAD/							
Agassiz	10 to 25	vgrloam	33	12	1	low	moderate
Mult	10 to 25	loam	0	38	2	moderate	low
AAF/							
Agassiz	25 to 60	vgrloam	33	12	1	low	high
Mult	25 to 60	loam	0	38	2	moderate	moderate
ACF/ Agassiz	25 to 60	vgrloam	33	12	1	low	high
BAD/ Baird Hollow	10 to 25	siloam	0	60	3	moderate	low
BJC/ Bulnell	4 to 15	loam	0	39	2	moderate	moderate
CDE/ Condie	25 to 40	grloam	20	60	5	moderate	low
CGF/ Cutoff	25 to 60	grloam	15	35	2	moderate	high
CHF/							
Cutoff	25 to 60	grloam	15	39	2	moderate	high
Falula	4 to 25	vgrloam	40	18	1	low	high
DAF/ Dagan	25 to 40	grsiloam	25	50	3	moderate	moderate
LEF/							
Lucky Star	25 to 60	grloam	20	60	3	moderate	low
Condie	25 to 60	grloam	20	60	5	moderate	moderate
MBE/							
Mirror Lake	10 to 30	grsloam	20	60	5	moderate	low
Sambrito	10 to 25	fsloam	0	60	5	moderate	moderate
MCD/							
Mult	10 to 25	loam	0	38	2	moderate	low
Agassiz	10 to 25	vgrloam	33	12	1	low	moderate
RFD/ Richens	10 to 30	loam	0	60	4	moderate	moderate

Soil Type/ Component	Slope* (%)	Texture*	Rock* (%)	Depth* (inches)	T Factor**	Compaction Potential ***	Severe Burning Hazard ***
RGF/							
Richens	30 to 60	loam	0	60	4	moderate	moderate
Agassiz	25 to 60	vgrloam	33	12	1	low	high
SDF/ Sambrito	25 to 60	fsloam	0	60	5	moderate	moderate
SGF/ Slinger	25 to 40	grloam	30	23	1	moderate	high
SHF/ Solak	25 to 50	grloam	25	15	1	moderate	high
SNF/ Sumine	10 to 50	stloam	15	28	1	moderate	high

Sources:

* *Soil Survey of Rich County, Utah, USDA NRCS, 1982*

***National Soil Survey Handbook, Exhibit 618.14, USDA NRCS, 2004 (T factor in tons/acre/year)*

*** *Soil Interpretive Guide, Intermountain Region (Region 4)*

Soil Sensitivity and Limitations to Management Activities

Table 3.8.1 indicates that there are no soil types with high potential for compaction in the analysis area (USDA Forest Service 1985).

The analysis area contains rocky, thin soils over bedrock with a low tolerance ("T" factor) for erosive soil loss (USDA NRCS 2004). This limitation is associated with the Agassiz, Falula, Solak, Slinger, and Sumine soil types, which are found on about 850 acres of the proposed treatment units. While the higher rock contents of these soils make them comparatively less susceptible to soil compaction, they cannot hold as much water from rainfall events as the deeper and less rocky soil types in the analysis area. This property, combined with the steep slopes these soil types are commonly found on, results in higher potential erosion rates. These soil types have comparatively less fertile conditions to support vegetation growth, and are comparatively more sensitive to soil losses from either erosion or severe soil burning.

Many of the soils in the area are covered by loamy topsoils, or by wind deposited fine sand or silt topsoils. Gravel and rock are for the most part absent from these topsoil layers. These conditions are found on about 3,635 acres of the proposed treatment units. The absence of gravel and rock makes these topsoils comparatively less resistant to compaction by heavy equipment during timber harvest activities, particularly on roads or main skidding and hauling trails with native soil surfaces.

Soil Quality Condition

Recent soil quality monitoring in the analysis area indicates that conditions of the soil resource are good and are currently meeting the desired conditions described in the Revised Forest Plan for the Bear Management Area. Although the analysis area is actively grazed by livestock in three separate allotments (Bug Lake, North and South Randolph), ground cover values within the areas being proposed for mechanical harvesting were consistently near 100%, not surprising considering the predominately coniferous overstory in these areas and their general lack of livestock forage. During July and August of 2006, extensive soil monitoring work was conducted on system roads in the area, and on previous timber harvest units and administratively closed or stabilized system and temporary roads associated with past harvest activities (Flood 2006b) This monitoring work detected isolated and small areas of poor soil quality conditions. Analysis of observations and data collected from monitoring plots resulted in the following conclusions and recommendations:

1. Soil disturbance on the 1983 Roundup 1 and Green Fork II timber sales was observed on the haul roads, main/secondary skid trails, and log landings. Soil productivity losses, as indicated by bare soil and reduced water infiltration rates, occurred on the wheel track portions of only the haul roads, main skid trails, and landings, or between 3.7% (Green Fork II) and 5.9% (Roundup 1) of the total area of the harvest units.
2. Erosion and sediment delivery from Forest Road 058 to the riparian bottom of New Canyon Creek was observed during a July 31, 2006 rainstorm event. This road is surfaced with native Sambrito soil material, and has had cross road drainage dips recently installed at 500 foot intervals.
3. Accelerated erosion and gullying were observed on steep gradient sections (> 8%) of temporary haul roads associated with the Green Fork and Green Fork II timber sales. These roads were built from native Sambrito soil type materials, and were closed and stabilized post sale with large dip structures.

Environmental Consequences

Introduction

This section will describe the potential direct, indirect, and cumulative effects that could occur to soil resources as a result of the proposed action and its alternatives. The area of analysis for all effects to the soil resource will be the individual activity areas represented by the proposed treatment units.

Effects to the soil resource will be disclosed in terms of the kind and amount of detrimental disturbance predicted or anticipated from the various types of proposed treatment activities. Detrimental disturbances are those that cause an unacceptable loss in soil quality or productivity. For silvicultural activities, detrimental disturbances may consist of accelerated soil erosion, soil compaction, severe soil burning, and/or herbicide persistence.

Key Assumptions

Potential soil erosion will be quantitatively analyzed using the FS WEPP model. Protocols, model inputs, and methodology used in the soil erosion analysis, as well as known limitations to the model, are presented in a separate report (Flood 2006a). Assumptions used in the erosion analysis include:

- Based upon the assumed time of complete recovery of ground protecting vegetation following completion of the activity, a six year return period was selected for the purpose of analyzing the hazard of WEPP modeled erosion rates to result in a detrimental soil disturbance.
- WEPP modeled erosion rates in excess of the allowable soil loss (“t” factor) for a given soil type will be assumed to result in a detrimental soil disturbance.
- As per Forest Plan direction, timber skidding with heavy equipment will not occur on slopes that exceed 40% gradient (USDA Forest Service 2003, p. 4-36).
- Timber skid trails are assumed to be an average of 11 feet wide, spaced an average of 125 feet apart, and have bare soil on 90% of their surface. Runoff diverting water bars or dips is assumed to occur along the skid trail at 50 foot intervals.

Potential soil compaction hazard will be qualitatively assessed based upon soil site properties and proposed treatment activity type. Assumptions used in the compaction assessment include:

- A potential soil compaction rating will be determined using the R4 compaction rating guide (USDA Forest Service 1985).

- Detrimental soil compaction will be assumed to have occurred on the temporary and intermittent service roads constructed for harvest activities, and on the main haul trails within harvest units, regardless of the soil compaction rating.
- Mechanical tree skidding with heavy equipment is assumed to result in detrimental soil compaction on soil types with a moderate rating only under moist or wet soil conditions.
- Based upon field monitoring of the previously harvested Roundup 1 timber sale on these moderately compactable soil types, timber skid trails are assumed to be an average of 11 feet wide, spaced an average of 125 feet apart, and have compacted soil on 45% of their surface (Flood 2006b).
- Soil compaction generated by the tractor used to pull a Dixie pipe harrow would be effectively eliminated with soil scarification done by the pipe harrow implement.

Severe soil burning hazards will be qualitatively assessed based upon soil site properties and existing fuel loads. Assumptions used in the severe burning assessment are found in the description of Potential Treatments for Sagebrush Mosaic Units in the Big Creek Vegetation Treatment FEIS (Corbin 2008) and also include:

- A severe soil burning hazard rating will be determined using the R4 prescribed burning rating guide (USDA Forest Service 1985).
- Detrimental soil burning will be assumed to have occurred where heavy fuel loading is found in treatment units dominated by soil types with a high hazard for severe soil burning.

Soil herbicide persistence will be qualitatively assessed here for all the action alternatives. The assessment will be based upon the relative persistence qualities of the chemicals proposed for use and the frequency of use being proposed. Assumptions used in the herbicide persistence assessment include:

- Relative soil persistence of proposed herbicides will be based upon the average soil half-life, using information from the Forest Noxious Weed Treatment Program FEIS (USDA Forest Service 2006e), and other references (US EPA 1995; USDOE 2000).
- Areas treated with any of the proposed herbicides will be assumed to not receive additional herbicide treatments for a minimum of 10 years.
- Proposed use of herbicides on this project will be conducted under a decision tree methodology used in the Forest Noxious Weed Treatment Program and using rationale that minimizes the use of known persistent herbicides. The decision tree and other rationale allows for the use of relatively more persistent agents only when less toxic and persistent agents are ineffective in controlling the target species.
- All herbicides will be applied at concentrations no greater than specified in their label, which further reduces the potential for impacts to soil productivity to occur as a result of these applications. (USDA Forest Service 2006e).

Effects Common to All Action Alternatives

Soil Erosion Effects

For the action alternatives, approximately 0.8 miles of machine fireline and about 14.3 miles of handline is expected to be constructed to contain prescribed fire activities within proposed unit boundaries. This will not significantly increase the amount of detrimental soil disturbance in any one unit to exceed the Forest Plan maximum of 15%. Following burning the lines will be rehabilitated (seeded and water barred as needed, and where available woody debris may be scattered along for microsite protection). Use of these erosion control measures will mitigate the potential for erosion.

Within the sagebrush/aspen mosaic stands proposed for treatment with mechanical disk or pipe harrowing, the direct effect on soil quality would be one of short-term soil disturbance occurring that would not be likely to result in significant amounts of soil erosion. The main reason why this is expected is that seeds from the existing vegetation are able to grow in the disturbed surface and vegetation is expected to grow back in the next year. (Condrat 2007).

Soil Burning Effects

Researchers (Fulton and West 2002) reviewed the effects of prescribed fire on water quality and several conclusions were reached. They found that "prescribed fire can impact water quality by heating the soil and killing soil organisms, thereby altering nutrient transformation rates and bioavailability. These impacts depend upon the severity and intensity of the fire. Prescribed burning of slash can increase erosion and sediment delivery to streams by eliminating protective cover and altering soil properties. …The degree of erosion after a prescribed burn depends on soil erodibility; slope; precipitation timing, volume, and intensity; fire severity; cover remaining on the soil; and speed of revegetation." They also stated "the following management measures were identified as ways to reduce the magnitude of the effects of fire on water quality: (1) limit fire severity, (2) avoid burning on steep slopes, and (3) limit burning on sandy or water repellent soils."

Although several adverse effects can occur from using prescribed fire, the land conditions within and around the burn treatment units make it likely that very little severe soil burning will occur or that the treatments will adversely affect soil quality. This is because the loading of heavy fuels is light, burning during early summer or fall should keep fireline intensities low, and the time period for vegetation to reoccupy the unit should be short, being about two years. Corbin reports that within the analysis area, fuel loading is generally moderate, and the largest contributor is in the 1000-hour fuels category. Fuels data collected for the analysis area indicates that about 12% of the plots have ground fuel loading that exceeds 70 tons per acre (Corbin 2007). These plots are located in treatment units 12, 13, 22, 24, and 29. Only units 22 and 39 are proposed to be treated with prescribed fire. Unit 22 contains the ACF (Agassiz) soil type with a high hazard for severe soil burning, and should only be treated in the spring when soil moisture content is at least 20% by volume.

Within the sagebrush/aspen mosaic stands proposed for treatment with prescribed fire, the direct effect on soil quality would be one of very little soil burning occurring and that severe soil burning would not occur. The main reason why this is expected is that the prescribed fire would burn quickly across the sagebrush and the residence time of the fire would not cause burning of the soil. Additional reasons that soil burning is unlikely using a prescribed fire is that prescribed fire would be conducted during the time of the year when relative humidity is high, no 100 and 1000 hour fuels would be present in the sagebrush, and the soils under aspen are relatively moist.

Past prescribed burns and wildfires in the analysis area have resulted in little or no severely burned soil, they have caused cumulatively insignificant effects on soil because of this and because they occurred over five years ago and the vegetation has been reestablished and the soil stabilized. Monitoring has shown that the Rock Creek and Monte Cristo burns followed the fire prescriptions determined for each area. Post burn monitoring of the Rock Creek burn revealed rapid growth of vegetation following the fire and no evidence was seen of erosion or sedimentation.

Soil Compaction Effects

None of the harvest treatment areas contained soil types with a high compaction hazard. Results of the qualitative soil compaction assessment indicate that detrimental soil compaction could occur in harvest units that contain soil types with moderate soil compaction potential ratings (see Table 3.8.1). However, field monitoring of nearby previously harvested timber sale units on similar soil types indicates that detrimental soil compaction would only occur only in the portion of proposed units associated with the sensitive soil types, and only on the temporary and permanent roads constructed for harvest activities, the main haul trails within harvest units, and on timber harvest/skid trails when soils are moist or wet.

Field monitoring of previously harvested timber sale areas indicates that detrimental soil compaction related to use of heavy equipment ranges from 3.9 to 5.7% of the harvested areas (Flood 2006b). Detrimentally compacted soil was found to be associated only with the temporary and permanent roads constructed for harvest activities and the main haul trails within harvest units. This potential soil compaction effect can be completely avoided on the timber harvest/skid trails by restricting ground based mechanical harvest and skidding to the normal dry operating season to mitigate the potential for detrimental compaction to occur when soils are moist or wet. Soil quality could be partially restored, but not to pre-timber harvest conditions, on the main haul trails, log landings, and temporary roads by mitigation practices such as ripping of the compacted soils and revegetating with native forbs and grasses.

No mitigation measures are required for harvest areas with a low soil compaction hazard.

For the action alternatives, approximately 0.8 miles of machine fireline is expected to be constructed to contain prescribed fire activities within proposed unit boundaries. Since soils in these units do not generally rate with a high compaction hazard (Flood, DEIS p. 3-66) and the number of passes along the line is limited, as well as the total mileage, it is not expected that soil compaction will be detrimental. This will not significantly increase the amount of detrimental soil disturbance in any one unit to exceed the Forest Plan maximum of 15%. Following burning, the lines will be rehabilitated (seeded and water barred as needed, and where available woody debris may be scattered along for microsite protection). Use of these erosion control measures will mitigate the potential for erosion.

Within the sagebrush/aspen mosaic stands proposed for treatment with mechanical disk or pipe harrowing, the direct effect on soil quality would be one of very little detrimental soil compaction occurring. The main reason why this is expected is that the pipe harrow implement would scarify and eliminate the small area of soil compaction created from the tractor used to pull the implement.

Soil Herbicide Persistence Effects

Within all the action alternatives, the sagebrush area treatments will be done using prescribed burning as the preferred tool over herbicide use or mechanical treatment, due to cost considerations. Herbicide application or mechanical methods would be used primarily where more precise targeting of vegetation is desired, where rabbit brush is present, or adjacent to private lands where fire is not appropriate. Chemicals proposed to be used in herbicide treatments include 2,4-D, picloram, and tebuthiuron. Methods proposed to be used in mechanical treatments are disking or Dixie harrowing.

Some types of herbicides, such as picloram or tebuthiuron, are known to persist within the soil for months or years after they have been applied (US EPA 1995; USDOE 2000). In the Big Creek project treatments the proposed use of herbicides is very unlikely to result in a reduction in soil quality/productivity as measured by the ability of the soil to support native vegetation. For soil productivity to be diminished, over the long term, herbicides would need to be persistent within the soil year after year. In this case, the less persistent herbicides such as 2,4-D are not likely to remain in the soil at concentrations toxic to plants for more than the growing season they are applied in. Unlike agricultural applications, the proposed herbicide treatments would not be repeated year after year. This would allow for the more persistent herbicides, such as picloram and tebuthiuron, to be naturally attenuated and broken down into less harmful components well before the next herbicide application occurs. This is estimated to be at least ten years. Finally, all herbicides will be applied at concentrations no greater than specified in their label, which further reduces the possibility of making the soil infertile from these applications.

a. Alternative 1 – Proposed Action

1. Direct and Indirect Effects

Soil Erosion Effects

For timber harvest and prescribed fire treatments, Tables 3.8.2 and 3.8.4 show the predicted erosion rates for each of the proposed treatment activity areas, separated according to type of treatment (harvest vs. prescribed fire).

Table 3.8.2. Erosion modeling summary – Proposed Action, timber harvest.

Soil Type/ Acres	Average Harvest Erosion*	Harvest Erosion 30 Year Event**	Harvest Erosion 6 Year Event**	Harvest Units	Harvest + Fire Units
AAD-Agassiz 19 ac	0	0	0	18, 26	none
AAF,ACF-Agassiz 129 ac	1.0	6.3***	1.7***	18, 19, 21 26-30, 32, 33	22, 45
BAD-Baird Hollow 280 ac	0	0	0	14, 17, 21, 34	36, 37, 39, 40, 47
BJC-Bullnell 35 ac	0	0	0	none	37-41, 43, 47, 50, 53, 54, 56, 57
CDE-Condie 5 ac	0.1	2.2	0	0	none
CGF,CHF-Cutoff 1 ac	0.7	4.6***	1.2	16	none
DAF-Dagan 32 ac	0.4	5.4***	0	2-4, 12, 15	6
LEF-Lucky Star 22 ac	0.8	4.6***	1.3	0, 5, 7	none
MBE-Mirror Lake 322 ac	0	0.1	0	23-26	22
MCD-Mult 155 ac	0	0	0	3, 30-33	50
RFD-Richens 138 ac	0	0	0	none	39, 50, 55, 57
RGF-Richens 97 ac	0.2	1.7	0.4	none	39, 45, 50, 57
SDF-Sambrito 1786 ac	0.2	1.8	0.5	0-8,10-19	9, 20, 48, 49
SNF-Sumine 9 ac	0.1	1.3***	0	none	48, 49

* in tons/acre/year; ** in tons/acre; *** rate exceeds “t” value for soil type

Results of erosion modeling using the FS WEPP methodology indicate that the average annual erosion rate for all proposed timber treatments is either at or below the allowable soil loss (“t” value) for the soil type. Long-term soil quality and productivity would therefore not be impaired by the timber treatments proposed under this alternative.

Table 3.8.2 shows that small amounts of detrimental soil erosion could periodically occur, as a result of the most probable type (six year return period) of rain fall event, in harvest units 18, 19, 21, 22, 26-30, 32, 33, and 45 (Flood 2006a). It should be noted that detrimental soil erosion is predicted to occur only in the portion of these units associated with the Agassiz soil types (AAF and ACF) found on steeply sloping ground, and only upon the timber skid trails within these units. Table 3.8.3 displays the size of each of these harvest units, the amount of the unit containing the Agassiz soil types, the potential acreage of timber skid trails on this soil type, and the percentage of the unit with potential detrimental soil erosion prior to any mitigation. This potential soil erosion effect can be completely avoided by following Revised Forest Plan standard S-1, which prohibits ground based timber skidding on the steeper slopes found in these soil types (USDA Forest Service 2003, p. 4-36).

Table 3.8.2 shows that additional harvest units could experience large amounts of detrimental soil erosion as a result of a 30 year return period storm event. The probability of a large storm event such as this occurring during the brief time frame of timber harvest and post harvest vegetation recovery is, however, very small. These soil losses would be episodic and infrequent in nature, and would not have an effect on long-term soil productivity or quality.

Table 3.8.3. Detrimental soil erosion proposed action, timber harvest.

Harvest Unit #	Total Acreage	Acres of Agassiz Soil Type	Skid Trail Acreage on Agassiz Soil	% of Unit with Detrimental Disturbance Possible (Prior to Mitigation Measures*)	% of Unit with Detrimental Disturbance Possible (Following Implementation of Mitigation Measures*)
18	110	2	0.3	0.3	0
19	38	7	1.1	2.9	0
21	70	3	0.4	0.6	0
22	99	13	2.1	2.1	0
26	66	18	2.9	4.4	0
27	35	35	5.6	16	0
28	16	16	2.6	16	0
29	12	12	1.9	16	0
30	5	5	0.8	16	0
32	29	2	0.3	1.0	0
33	89	15	2.4	2.7	0
45	12	1	0.2	1.7	0

*Mitigation Measures are described in Chapter 2, Section 2.2, under “Design Elements and Mitigation Measures Common to Alternatives 1 and 3,” Table 2.2.1b.

Results of erosion modeling using the FS WEPP methodology indicate that the average annual erosion rate for all proposed prescribed fire treatments is either at or below the allowable soil loss (“t” value) for the soil type, and that none of the prescribed fire treatment units would experience detrimental soil erosion as a result of the most probable type of rainstorm. Long-term soil quality and productivity would therefore not be impaired by the prescribed fire treatments proposed under this alternative.

Table 3.8.4 shows that some of the prescribed fire units could experience large amounts of detrimental soil erosion as a result of a 30 year return period storm event. The probability of a large storm event such as this occurring during the brief time frame of burning and post fire vegetation recovery is, however, very small. These soil losses would be episodic and infrequent in nature, and would not have an effect on long-term soil productivity or quality.

Table 3.8.4. Erosion modeling summary – Proposed Action, prescribed fire.

Soil Type/Acres	Average RX Fire Erosion*	Rx Fire Erosion 30 Year Event**	Rx Fire Erosion 6 Year Event**	Rx Fire Units
AAF,ACF-Agassiz 6 ac	0.2	2.6***	0	46, 62
BAD-Baird Hollow 450 ac	0	0	0	35, 59-63
BJC-Bullnell 903 ac	0	0	0	35, 52, 63
CGF,CHF-Cutoff 948 ac	0.3	4.1***	0	58-62
DAF-Dagan 66 ac	0.4	4***	1.1	58, 64
MCD-Mult 40 ac	0	0	0	46, 58, 62
RFD-Richens 64 ac	0	0.5	0	35, 52, 63
RGF-Richens 85 ac	0.1	1.3	0	35, 42, 44, 46 51, 52
SDF-Sambrito 28 ac	0.1	1.6	0	58, 59, 62, 64
SGF-Slinger 3 ac	0.2	3.5***	0	62
SHF-Solak 57 ac	0.2	3.9***	0	59
SNF-Sumine 201 ac	0.2	2.7***	0	35, 63

- - in tons/acre/year; ** - in tons/acre; *** - rate exceeds "t" value for soil type

Soil Compaction Effects

Based upon field monitoring of previous timber harvest activities in the area, between 62 and 90 acres of the 1,600 acres of National Forest System land proposed for mechanical harvest treatments under the proposed action could potentially have detrimental soil compaction after completion of the activity. It should be noted that detrimental soil compaction would occur only in the portion of these units associated with the sensitive soil types (see Table 3.8.1), and only on the temporary and intermittent service roads constructed for harvest activities, the main haul trails within harvest units, and on timber harvest/skid trails when soils are moist or wet. However with the implementation of recommended mitigation measures and project design features to limit detrimental soil disturbance, this potential soil compaction effect can be completely avoided on the timber harvest/skid trails.

Under the proposed action, construction of temporary and intermittent service roads to access the individual harvest units could be expected to produce about 13 acres of compacted soil. Although these effects would not be a permanent impairment of soil productivity, full recovery of soil quality would not occur within the ten year timeframe for analysis of future effects. Soil quality could be partially restored, but not to pre-timber harvest conditions, on the main haul trails, log landings, and temporary roads by mitigation practices such as ripping of the compacted soils and revegetating with native forbs and grasses.

b. Alternative 2 – No Action

1. Direct and Indirect Effects

Soil quality will remain unchanged from existing conditions.

c. Alternative 3 – Reduced Treatment and Wildlife Emphasis

1. Direct and Indirect Effects

This section describes the effects to soil resources from the treatments proposed under Alternative 3.

Soil Erosion Effects

For timber harvest and prescribed fire treatments, Tables 3.8.5 and 3.8.7 show the predicted erosion rates for each of the proposed treatment activity areas, separated according to type of treatment (harvest vs. prescribed fire).

Table 3.8.5. Erosion modeling summary – Alternative 3, timber harvest.

Soil Type/ Acres	Average Harvest Erosion*	Harvest Erosion 30 Year Event**	Harvest Erosion 6 Year Event**	Harvest Units	Harvest + Fire Units
AAD-Agassiz 19 ac	0	0	0	15, 21	none
AAF,ACF-Agassiz 99 ac	1	6.3***	1.7***	15, 17, 21-24	18
BAD-Baird Hollow 118 ac	0	0	0	11, 14, 17	none
BJC-Bullnell 24 ac	0	0	0	none	26-28, 31, 33, 34, 36, 37
CDE-Condie 5 ac	0.1	2.2	0	0	none
CGF,CHF-Cutoff 1 ac	0.7	4.6***	1.2	13	none
DAF-Dagan 10 ac	0.4	5.4***	0	2, 12	4
LEF-Lucky Star 22 ac	0.8	4.6***	1.3	0, 3, 5	none
MBE-Mirror Lake 299 ac	0	0.1	0	19-21	18
MCD-Mult 11 ac	0	0	0	none	31
RFD-Richens 103 ac	0	0	0	none	31, 35, 37
RGF-Richens 66 ac	0.2	1.7	0.4	none	31, 37
SDF-Sambrito 250 ac	0.2	1.8	0.5	0-3, 5, 6, 8-15	7, 16
SNF-Sumine 9 ac	0.1	1.3***	0	none	29, 30

* in tons/acre/year; ** in tons/acre; *** rate exceeds “t” value for soil type.

Results of erosion modeling using the FS WEPP methodology indicate that the average annual erosion rate for all proposed timber treatments is either at or below the allowable soil loss (“t” value) for the soil type. Long-term soil quality and productivity would therefore not be impaired by the timber treatments proposed under this alternative.

Table 3.8.5 shows that small amounts of detrimental soil erosion could periodically occur, as a result of the most probable type (six year return period) of rain fall event, in harvest units 18, 21, and 26-29 (Flood 2006a). It should be noted that detrimental soil erosion is predicted to occur only in the portion of these units associated with the Agassiz soil types (AAF and ACF) found on steeply sloping ground, and only upon the timber skid trails within these units. Table 3.8.6 displays the size of each of these harvest units, the amount of the unit containing the Agassiz soil types, the potential acreage of timber skid trails on this soil type, and the percentage of the unit with potential detrimental soil erosion prior to any mitigation. This potential soil erosion effect can be completely avoided by following Revised Forest Plan standard S-1, which prohibits ground based timber skidding on the steeper slopes found in these soil types (USDA Forest Service 2003, p. 4-36).

Table 3.8.5 shows that additional harvest units could experience large amounts of detrimental soil erosion as a result of a 30 year return period storm event. The probability of a large storm event such as this occurring during the brief time frame of timber harvest and post harvest vegetation recovery is, however, very small. These soil losses would be episodic and infrequent in nature, and would not have an effect on long-term soil productivity or quality.

Table 3.8.6. Detrimental soil erosion Alternative 3, timber harvest.

Harvest Unit #	Total Acreage	Acres of Agassiz Soil Type	Skid Trail Acreage on Agassiz Soil	% of Unit with Detrimental Disturbance Possible (Prior to Mitigation Measures*)	% of Unit with Detrimental Disturbance (Following Implementation of Mitigation Measures*)
15	110	2	0.3	0.3	0
17	70	2.6	0.4	0.6	0
21	66	18	2.9	4.4	0
22	35	35	5.6	16	0
23	16	16	2.6	16	0
24	12	12	1.9	16	0

*Mitigation Measures are described in Chapter 2, Section 2.2, under "Design Elements and Mitigation Measures Common to Alternatives 1 and 3" Table 2.2.1b.

Results of erosion modeling using the FS WEPP methodology indicate that the average annual erosion rate for all proposed prescribed fire treatments is either at or below the allowable soil loss ("t" value) for the soil type, and that none of the prescribed fire treatment units would experience detrimental soil erosion as a result of the most probable type of rainstorm. Long-term soil quality and productivity would therefore not be impaired by the prescribed fire treatments proposed under this alternative.

Table 3.8.7 shows that some of the prescribed fire units could experience large amounts of detrimental soil erosion as a result of a 30 year return period storm event. The probability of a large storm event such as this occurring during the brief time frame of burning and post fire vegetation recovery is, however, very small. These soil losses would be episodic and infrequent in nature, and would not have an effect on long-term soil productivity or quality.

Table 3.8.7. Erosion modeling summary Alternative 3, prescribed fire.

Soil Type/Acres	Average RX Fire Erosion*	Rx Fire Erosion 30 Year Event**	Rx Fire Erosion 6 Year Event**	Rx Fire Units
AAF,ACF-Agassiz 5 ac	0.2	2.6***	0	42
BAD-Baird Hollow 560 ac	0	0	0	25, 39-43
BJC-Bullnell	0	0	0	25, 32, 43

Soil Type/Acres	Average RX Fire Erosion*	Rx Fire Erosion 30 Year Event**	Rx Fire Erosion 6 Year Event**	Rx Fire Units
903 ac				
CGF,CHF-Cutoff 1032 ac	0.3	4.1***	0	38-42
DAF-Dagan 140 ac	0.4	4***	1.1	38
MCD-Mult 36 ac	0	0	0	42
RFD-Richens 64 ac	0	0.5	0	25, 32, 43
RGF-Richens 78 ac	0.1	1.3	0	25, 32
SDF-Sambrito 19 ac	0.1	1.6	0	38, 39, 42
SGF-Slinger 3 ac	0.2	3.5***	0	42
SNF-Sumine 201 ac	0.2	2.7***	0	25, 43

*- in tons/acre/year; ** - in tons/acre; *** - rate exceeds “t” value for soil type

Soil Compaction Effects

Based upon field monitoring of previous timber harvest activities in the area between 40 and 60 acres of the 1,040 acres of National Forest System land proposed for mechanical harvest treatments could potentially have detrimental soil compaction after completion of the activity. It should be noted that detrimental soil compaction would occur only in the portion of these units associated with the sensitive soil types (see Table 3.8.1), and only on the temporary and intermittent service roads constructed for harvest activities, the main haul trails within harvest units, and on timber harvest/skid trails when soils are moist or wet. However with the implementation of recommended mitigation measures and project design features to limit detrimental soil disturbance, this potential soil compaction effect can be completely avoided on the timber harvest/skid trails.

Under Alternative 3, construction of temporary and intermittent service roads to access the individual harvest units could be expected to produce about 7.5 acres of compacted soil. Although these effects would not be a permanent impairment of soil productivity, full recovery of soil quality would not occur within the ten year timeframe for analysis of future effects. Soil quality could be partially restored, but not to pre-timber harvest conditions, on the main haul trails, log landings, and temporary roads by mitigation practices such as ripping of the compacted soils and revegetating with native forbs and grasses.

d. Cumulative Effects to the Soil Resources

Scope of Analysis – The scope of the cumulative analysis identifies significant issues, the geographic area, time frame for analysis, and other actions affecting the resources of concern. The significant cumulative effects issue related to soil resources is that certain past, present, and reasonably foreseeable future management activities have the potential to create disturbances to soils. These disturbances could consist of detrimental amounts of erosion, compaction, severe burning, or herbicide accumulation. The indicator for cumulative effects is the kind and amount of detrimental disturbance observed, predicted, or anticipated from the various types of management activities that have the potential to create disturbances to soils. The geographic area for the analysis of cumulative effects to soils will be the individual activity areas represented by the proposed treatment units and the roads constructed to access them. The time frame for the analysis of reasonably foreseeable actions is about 10 years, which represents the approximate length of time required for areas detrimentally disturbed by prescribed fire, timber harvest, or road building activities to become stabilized with ground protecting native vegetation. The time frame for the analysis of past actions is about 100 years.

Affected Environment – Other actions that may have an influence on soil, water, and aquatic resources are livestock grazing, motorized roads and trails, dispersed recreation, and vegetation treatment. Sheep and cattle grazing is a permitted activity that has been occurring for over 100 years in the analysis area, and is expected to continue in the future. Motorized roads and trails, and dispersed recreation use is occurring now in the analysis area, and is expected to occur in the future. Within the geographic area for the analysis of cumulative effects to soils, none of the areas proposed for vegetation treatments have received timber harvest or prescribed fire treatments in the past. Additional vegetation treatments beyond those being proposed under the action alternatives are not foreseen for these areas in the future.

Determination of Cumulative Effects - Several effects may occur from other activities occurring within the cumulative effects area. Generally, grazing may cause erosion and sedimentation by shearing soil and leaving bare surface soil that can erode during storm events. Motorized roads and trails have the potential to erode during storm events that may cause sedimentation of streams if they are close by. Dispersed recreation may cause soil disturbance and trampling that may lead to erosion and sedimentation.

No Action Alternative - Cumulative Effects

The effects of previous and current management activities are disclosed under the section "Soil Resource Features and Conditions."

Cumulative Effects of the Action Alternatives

Based upon the following analysis**,** cumulative effects to the soil resource from the proposed action and its alternatives would consist of existing amounts of detrimental disturbance in treatment units 15, 23, 25, 26 (disclosed in further detail below) and the 7.5 acres (Alternative 3) to 13 acres (Proposed Action) of detrimentally compacted soil associated with the construction of temporary and intermittent service roads to access the individual harvest units.

With the implementation of recommended mitigation measures and project design features to limit detrimental soil disturbance, the proposed action or its alternative will have very little direct or indirect effects on soil quality. None of the proposed treatments are likely to experience detrimental soil erosion, compaction, severe burning, or herbicide accumulation as a result of either mechanical, chemical, prescribed fire treatments. Proposed prescribed burns will also have mitigation included to minimize severe burning impacts to soils.

Within the cumulative effects analysis geographic area, the majority of the areas proposed for vegetation treatments have not been affected by previous timber harvests, wildfire, prescribed fire, or herbicide treatments. The units proposed for vegetation treatments that have been affected by previous timber harvests or past fire activity are shown in the Table 3.8.8.

Table 3.8.8. Units proposed for vegetation treatments that have been affected by previous timber harvests or past fire activity.

Past Activity	Name	Year	Acre	Alt	Unit
Seed Cut	Pole Canyon Sale	1998	15	2/3	15
Partial Cut	Campground Springs Sale	1986	67	2/3	23
Individual Tree	Curtis Salvage Sale	2000	39	2/3	26
Individual Tree	Spencer Basin Sale	1965	5	2	25
Clear Cut	Green Fork Sale	1983	12	2	58

Past Activity	Name	Year	Acre	Alt	Unit
Wildfire	Green Fork	1999	5	2/3	3
Wildfire	Green Fork	1999	35	2	58
Prescribed Fire	Big Crawford Range Rx	1992	9	2	31
Prescribed Fire	Big Crawford Range Rx	1992	10	2	34
Prescribed Fire	Big Crawford Range Rx	1990	173	2	35
Prescribed Fire	Big Crawford Range Rx	1992	3	2/3	36
Prescribed Fire	Big Crawford Range Rx	1992	4	2/3	37
Prescribed Fire	Big Crawford Range Rx	1992	3	2/3	38
Prescribed Fire	Big Crawford Range Rx	1992	15	2/3	39
Prescribed Fire	Big Crawford Range Rx	1992	18	2/3	40
Prescribed Fire	Big Crawford Range Rx	1990	11	2	47
Prescribed Fire	Big Crawford Range Rx	1990	5	2	52

Field monitoring of previously harvested timber sale areas (including Green Fork, Spencer Basin, and Campground Spring sale units) indicates that detrimental soil compaction related to use of heavy equipment ranges from 3.9 to 5.7% of the harvested areas (Flood 2006b). This analysis assumes that existing detrimental soil disturbance in each of the above areas falls within that range.

Field monitoring of past prescribed burns and wildfires in the analysis area has detected little or no severely burned soil. Past fire activity has caused cumulatively insignificant effects on soil because of this and because the fires occurred over five years ago and the vegetation has been reestablished and the soil stabilized. Monitoring has shown that the Rock Creek and Monte Cristo burns followed the fire prescriptions determined for each area. Post burn monitoring of the Rock Creek burn revealed rapid growth of vegetation following the fire and no evidence was seen of erosion or sedimentation. Furthermore, the intent of the prescribed fire/mechanical/herbicide treatments is to not target previously treated areas. However, some slop-over of prescribed burning into these areas may occur (Corbin 2008)

Several existing system roads that will be used to access the proposed treatment areas are currently experiencing accelerated erosion. These roads have been previously identified and analyzed under the section "Soil Resource Features and Conditions." Implementation of required mitigation measures for the action alternatives will result in a cumulative reduction in erosion on these roads.

All of the proposed vegetation treatments are within currently permitted livestock grazing allotments. Sheep and cattle grazing resulted in high impacts to soil resources from the 1800s until the 1930s when active grazing management took effect in the area. Since then, a gradual improvement in land conditions has occurred as indicated by increased ground cover and absence of active soil erosion in most areas within grazing allotments. Current grazing activities are not having a detrimental effect upon soil quality within the cumulative effects analysis geographic area. Field monitoring of past timber harvest (Roundup 1 and Green Fork 2 sale units) and prescribed burn (Rock Creek Rx Burn) treatments either in or adjacent to the analysis area did not detect any indications that permitted livestock was grazing within these areas of regenerating forest (Flood 2006b). Also, ground cover values within the areas being proposed for mechanical harvesting were consistently near 100%, not surprising considering the predominately coniferous overstory in these areas and their general lack of livestock forage.