Beartooth Front Storm Damage Clean-up And Fuels Reduction Project

SOILS SPECIALIST REPORT

Beartooth Ranger District
Custer National Forest
Northern Region

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Executive Summary

The Beartooth Front Storm Damage Cleanup and Fuels Reduction project area was surveyed to detail existing condition and determine potential effects to the soil resource. Based on field reconnaissance, review of literature, and GIS analysis, impacts to long term soil productivity are not anticipated from any of the proposed activities. Mechanical treatments would not exceed regional thresholds assuming existing routes are maximized and dry conditions exist. No adverse impacts from hand piling/burning would occur. The analysis found little of the area was impaired from current cattle use, and recreational activities. Long term cumulative effects are not anticipated since regrowth of the grassland/shrubland understory is high and that mechanical fuels treatments would maximize use of existing travel routes to limit disturbance.

The project area was visited and surveyed in May 1, 2008 (Benbow Area) and June 13, 2008 (Main Fork). Field review consisted of traversing representative units and assessing soil parameters as well as visually estimating existing disturbance. It is estimated that less than 3% of the area was detrimentally disturbed.

The majority of the soils on sampled sites are coarse textured, having a high cobble and gravel content. This is a sign that they will resist erosion. A majority of these sites also have subangular blocky or granular structures. This is an indicator that these sites do not have residual compaction or detrimental effects from historic management. There is very little bare ground, a sign of resistance to erosion and most sites have high coarse woody debris content, reflecting a historic buildup of woody material from fire exclusion.

Long term impacts to soils are not anticipated from the proposed treatments. The soil analysis indicates that all alternatives and all activities proposed would meet the Region 1 Soil Quality Standards through the implementation of management practices outlined in Design Criteria and restoration of landings and heavily used skid trails, if needed, to reduce the total amount of detrimental soil impacts. The existing condition indicates there is little detrimental soil disturbance throughout the project area. All Forest Plan management direction would be met by the proposed action.

Background

The Beartooth Storm Damage Cleanup and Hazardous Fuels Removal Project area is located on the Beartooth Ranger District, Custer National Forest in Carbon and Stillwater Counties in South-central Montana. The project area consists predominately of major valleys in the Rock Creek drainage and mountain slopes and drainages in the Benbow area. Elevations in the project area range from around 5,000 feet to over 12,000 feet. Major vegetation types are lodgepole pine, and Douglas fir and some aspen.

Existing Conditions

The soils of the project area are currently being mapped as part of the Beartooth Mountain Area Terrestrial Ecological Unit Inventory and will be correlated by the Natural Resource Conservation Service (NRCS) as part of the Soil Survey of the Absaroka-Beartooth Wilderness Area, Eastern Half. The major Landtype in the Benbow area is outwash moraine deposits, in the Main Fork area the major Landtype is Valley Bottoms. (See Table 1 for the proposed treatment units and draft Landtype units acreage.)

Table 1. Project Treatment units and draft Landtype acres.

Location	Project Treatment Unit	TEUI Premap	Landtype Name	Acres
Benbow	01	45	Fishtail Creek outwash moraine deposits	49.56
Benbow	01	55	Landflows	16.76
Benbow	02	45	Fishtail Creek outwash moraine deposits	29.66
Benbow	03	45	Fishtail Creek outwash moraine deposits	59.89
Benbow	03	71	Triassic-Cretaceous Sedimentary	14.66
Benbow	54	71	Triassic-Cretaceous Sedimentary	35.23
Benbow	55	71	Triassic-Cretaceous Sedimentary	0.97
Benbow	56	45	Fishtail Creek outwash moraine deposits	0.98
Benbow	56	71	Triassic-Cretaceous Sedimentary	14.44
Benbow	57	45	Fishtail Creek outwash moraine deposits	17.77
Benbow	58	45	Fishtail Creek outwash moraine deposits	28.34
Benbow	59	45	Fishtail Creek outwash moraine deposits	19.71
Benbow	60	45	Fishtail Creek outwash moraine deposits	88.93
Main Fork	41	31	Glacial troughs	4.44
Main Fork	41	62	Valley bottoms - high elevation (ca. >2100 m)	32.69
Main Fork	42	62	Valley bottoms - high elevation (ca. >2100 m)	9.55
Main Fork	43	62	Valley bottoms - high elevation (ca. >2100 m)	33.27
Main Fork	44	62	Valley bottoms - high elevation (ca. >2100 m)	16.76
Main Fork	45	62	Valley bottoms - high elevation (ca. >2100 m)	39.67
Main Fork	46	62	Valley bottoms - high elevation (ca. >2100 m)	5.96
Main Fork	47	31	Glacial troughs	5.08
Main Fork	47	62	Valley bottoms - high elevation (ca. >2100 m)	82.09
Main Fork	48	31	Glacial troughs	0.10

Main Fork	48	62	Valley bottoms - high elevation (ca. >2100 m)	7.79

The predominate soils are derived from glacial outwash and are coarse textured with abundant gravel, cobbles, and boulders and are moderately deep to deep to bedrock.

The project area was visited and surveyed in May 1, 2008 (Benbow Area) and June 13, 2008 (Main Fork). Field review consisted of traversing representative units and assessing soil parameters as well as visually estimating existing disturbance. Table 2 and Table 3 show which proposed units were visited for field assessment. It is estimated that less than 3% of the area was detrimentally disturbed.

The majority of the soils on sampled sites are coarse textured, having a high cobble and gravel content. This is a sign that they will resist erosion. A majority of these sites also have subangular blocky or granular structures. This is an indicator that these sites do not have residual compaction or detrimental effects from historic management. There is very little bare ground, a sign of resistance to erosion and most sites have high coarse woody debris content, reflecting a historic buildup of woody material from fire exclusion.

There is some evidence of stumps and in some locations old trails. Stumps appear to be small and a result of firewood cutting or post and pole harvest units. The trails appear to be from ATV's or are associated with dispersed recreation sites. Most of the units in the Main Fork and West Fork of Rock Creek are along the road where these areas get a lot of recreation use, both at dispersed and developed sites. No units were identified as having previous commercial timber sale activities.

Table 2. Proposed treatment units, treatment method, and field assessment for the Benbow area.

Unit number	Unit acres	Proposed treatments	Treatment Method	Field Assessment for Soil Quality
1	66	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine and hand	
2	30	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	
3	75	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	Traverse
54	35	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	
55	1	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	

56	15	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	
57	18	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	
58	28	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine and hand	Traverse
59	20	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	Traverse
60	89	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	ID Team Leader and Group
TOTAL BENBOW ACRES = 377				

Table 3. Proposed treatment units, treatment method, and field assessment for the Main Fork area.

Unit number	Unit acres	Proposed treatments	Treatment Method	Field Assessment for Soil Quality
41	37	Remove and salvage windfall and wind-damaged trees along US Highway 212 [1].	Machine	Traverse
42	10	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	
43	33	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	Traverse
44	17	Thin remaining live trees in Parkside Campground [2].	Machine	
45	40	Thin remaining live trees in Greenough Lake Campground and recreation site [2].	Machine	Traverse
46	6	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	Traverse
47	87	Remove and salvage windfall and wind-damaged trees [1]. Thin remaining live trees [2].	Machine	Traverse
48	8	Remove and salvage windfall and wind-damaged trees in MK Campground [1]. Thin remaining live trees in MK Campground [2].	Machine	Traverse
TOTAL MAIN FORK ACRES = 238				

Affected Environment

This section discusses the components of the soil resource that could be affected by the proposed activities. They are:

- Soil productivity
- Soil erosion
- Mass failure or soil stability

Soil Productivity

Soil productivity is the ability of the soil to supply the water and nutrients needed to sustain plant growth. Characteristics that influence soil productivity include physical soil characteristics, organic matter and soil organisms.

Physical Soil Characteristics

Soil properties and forest productivity can be affected by heavy equipment used for harvest and site preparation but these impacts vary greatly with site conditions and operational practices (Ares et al., 2005). The physical characteristics of concern are soil depth, the amount of pore space in the soil, and the density of the soil. These activities compress or compact soils and if soils are wet enough cause rutting and puddling. All of these changes to the physical soil characteristics reduce the amount of pore spaces. This in turn reduces the movement of water into and through the soil and impedes root growth through soils, reducing a plant's ability to take up water and nutrients. Compaction and other physical soil disturbances alter the amount of carbon dioxide and oxygen in the soil, affecting both plants and animals that live in or on the soil.

Organic Matter

Organic matter in its various forms contributes to soil productivity. Humus is decomposed organic matter. Duff and litter consist of fresh or partially decomposed leaves, needles, and twigs that are still recognizable on the surface of soils. Large woody debris consists of woody stems greater than three inches in diameter (Harvey, et al. 1994, p.10). Decomposed large woody debris supplies moisture to plants after the soils dry out. All organic matter provides water and nutrients for soil organisms and plants, though the contribution of nutrients from large woody debris, in some forests, is relatively minor (Prescott and Laiho, 2002, p. 390).

Soil Organisms

Soil organisms, including fungi and bacteria, drive nutrient cycling by decomposing organic matter, which releases nutrients for plant growth. Soil organisms depend on organic matter for the nutrients they need to carry out their life processes. Decomposed large woody debris provides important habitat for the survival of mycorrhizae fungi. These fungi form a symbiotic relationship with tree roots, increasing water and nutrient uptake by the trees and the fungi (Perry, et al. 1990, p. 268).

Soil Erosion

Soil erosion is the detachment and movement of soil particles by water, wind, ice, or gravity. Erosion occurs when the soil lacks protective vegetative cover. Soil erosion reduces the productivity of the land by loss of water, soil organic matter, nutrients, biota, and depth of soil (Pimentel and Kounang, 1998). Water is the main cause of soil erosion

on steep forested slopes. Erosion is usually minimal on undisturbed forest soils for two reasons: first, abundant organic matter provides a protective blanket on the soil surface that reduces the impacts of raindrops and allows water to move into the soil; second, the surface soil below the organic layer is by its nature porous, allowing water to move rapidly into and through the soil profile.

Soil erosion can occur when the surface soil is compacted or when the loose surface soil and its protective layer of organic material are changed by management activities. Compaction, rutting, and puddling reduce the movement of water into the soil and tend to channel and concentrate water. As a result, water runs off (overland flow) and carries soil particles with it. Natural occurrences such as fire remove organic matter from the soil surface. When organic matter is removed, soil pores can be plugged by impact from raindrops resulting in overland flow and soil erosion.

Mass Wasting

Mass wasting, also known as **mass movement** or **slope movement**, is the geomorphic process by which soil, regolith, and rock move downslope under the force of gravity. Types of mass wasting include creep, slides, flows, topples, and falls, each with their own characteristic features, and take place over timescales from seconds to years. Mass wasting can either be natural or man-caused disturbances. Mass failures can result when a sequence of natural events, such as high precipitation or snowmelt, are followed by a trigger such as an earthquake. Some areas are prone to mass wasting because of the nature of the geology or soil. Human disturbances such as roads can cause mass failures if road surface drainage is concentrated enough to saturate soils. Mass failures triggered by human causes are detrimental soil disturbances. These disturbances cause long-term changes in soil productivity that last centuries.

Soil Quality

Forest Service Manual Section 2550 and the Region 1 Supplement 2500-99-1 provide direction for maintaining soil quality. In addition, monitoring for activities on soils similar to those proposed are used to analyze the effects of the proposed activities. The information gathered in the field was used to conduct the effects analysis.

Analysis Area Description

The analysis area forms the boundary for the direct, indirect and the cumulative effects soils analysis. It consists of the proposed activity areas for the Beartooth Front Storm Damage Clean-up And Fuels Reduction Project. This analysis area was selected because that is where the effects of implementing the proposed activities would occur. The effects on soils would not extend beyond the proposed treatment.

Environmental Consequences

The analysis of effects for soils assumes that all of the practices outlined in Design Features and Mitigation Measures Specific to the Proposed Action (see project file), would be implemented and would be effective. The analysis will show the expected

amount of soil disturbance resulting from implementation of the alternatives, and will also describe the risk that the expected amount of disturbance would be exceeded.

Direct, indirect and cumulative effects are discussed in terms of the activity areas. The Region 1 Supplement 2500-99-1 (see project file) defines an activity area as a land area affected by a management activity to which soil quality standards are applied. An example is a harvest unit within a proposed timber sale.

The soils analysis is based on the current soil condition and analyzes the soil effects caused by implementation of the proposed management activities. Soil effects are a result of detrimental soil disturbances. Detrimental disturbances are defined in Forest Service Manual FSM R-1 Supplement No. 2500-99-1 (see project file) as the condition where established soil quality standards are not met and the result is a change in soil quality. This Manual also states that at least 85 percent of an activity area be maintained in satisfactory soil conditions.

The Manual defines the Regional soil quality guidelines in terms of detrimental soil disturbance, which includes:

- Compaction
- Rutting
- Displacement
- Severely-burned Soil
- Surface Erosion
- Soil Mass Movement (Mass Failure)

Detrimental soil disturbances are the basis for the effects analysis of the Beartooth Front Storm Damage Clean-up And Fuels Reduction Project. However, not all soil disturbance have a detrimental effect on soil productivity. For example, loss of less than one inch of topsoil over less than 100 square feet is not a detrimental soil disturbance nor is light compaction that causes less than a 15 percent increase in bulk density or that does not elevate bulk density to levels that impede root growth (See Forest Service Manual FSM R-1 Supplement No. 2500-99-1 in the project file).

Direct and Indirect Effects of No Action

A no action scenario provides a baseline to evaluate the effects of the proposed action. The effects on soils are discussed as changes over time on soil productivity and soil erosion.

Soil Productivity

Doing nothing would not cause short-term effects on the soil resource over and above the existing condition. No additional thinning, fuels reduction, prescribed burning, or road management activities would disrupt the natural soil processes.

Physical Soil Disturbances

No soil compaction, rutting, puddling, or soil displacement would occur with no action. Soils that are undisturbed would remain so. Soil productivity in areas with compacted

soils would slowly improve as plant roots, soil organisms, and freeze-thaw events loosen the soil. Sites that are slightly compacted would recover in fewer years.

Organic Matter

With no action, standing dead and damaged trees, downed trees, needles and branches would remain on the site and fall to the ground. All standing dead trees would eventually fall over and contribute coarse woody debris. Soil organisms would decompose the organic materials thus adding humus to the soil. Nutrients associated with this material would slowly become available for plant growth. As the tree canopies close in and shade the soil surface, decomposition rates would slow, allowing organic matter and nutrients to accumulate on the soil surface. This process would continue until another major disturbance such as fire or a windstorm opens the tree canopy and speeds up the recycling process again.

An intense wildfire is a possibility at some time in the future. An intense fire event would reduce the amount of organic matter and associated nutrients in the area. Historically, in the Beartooth Ranger District forests generally recover over time following wildfires. Depending on the severity of the fire the time frame could be as long as decades.

Soil Organisms

Microorganism populations would fluctuate with the changes in the microclimate and the organic matter on the soil surface. These changes would be in response to the changing vegetation as a result of natural events such as fire, insect, and disease. The changes would be temporary because of the mobility of soil organisms.

Soil Erosion

Soil erosion would decrease as vegetation returns to soils that lack plant cover. Wildland fires would probably cause a short-term increase in soil erosion. An extreme wildfire followed by a severe rain event could lead to accelerated erosion and sedimentation, and possible mass wasting. Soil erosion rates would fluctuate with natural changes in vegetation.

Direct and Indirect Effects of Proposed Action

Soil Productivity

The objective of soil management is to reduce detrimental soil disturbance by limiting the area used by mechanical equipment, skid trails and landings and by implementing timing and equipment requirements (Soil design features) that have the potential to reduce the amount and degree impacts on the skid trails.

Physical Soil Characteristics

All direct effects on soil physical characteristics would occur within the boundaries of the proposed activity areas. More specifically, most detrimental effects would be concentrated on areas used by mechanical equipment and the skid trails, temporary roads and landings used in commercial timber sale operations. Reduced productivity is caused

by detrimental soil disturbances such as soil compaction, displacement, rutting, or soil erosion. The proposed treatment areas, if treated as part of commercial timber sales, would be harvested using designated trails and landings that are laid out to occupy less than 15 percent of the activity unit. Utilizing existing roads and trails in previously disturbed areas will also reduce the amount of new disturbance. Minimizing the area occupied by fuels piles, landings, and skid trails to reduce the detrimental effects on soil productivity from changes in physical soil properties is recommended in several papers (Adams, 1998;Garland, 1997; Williamson and Nielson, 2000).

The proposed treatment areas would be harvested using designated trails and landings that are laid out to occupy less than 15 percent of the activity unit. Garland (1997) noted in a paper on minimizing soil effects from timber harvest that designated skid trails spaced 100 feet apart impact 11 percent of the harvest area.

In addition to using designated skid trails and landings, there is a potential to further reduce soil effects to the extent possible, by operating equipment on skid trails when the soils are drier than field moisture capacity or in winter. Startsev and McNabb (2001), and McNabb et al., (2001) found that soil compaction is reduced when soils are drier than field capacity. Williamson and Nielson (2000) noted that rutting and puddling are most often associated with logging on soils that are wet. Most summer logging would occur when soils are drier than field capacity. Operating on low soil moisture conditions has the potential to reduce the detrimental disturbance on skid trails. Thus the area with detrimental disturbance has potential to be less than the area of skid trails and landings.

A thesis by Sang-Kyun Han (2006) that looked at the effects of cut to length harvesting systems showed that heavy slash (about 40 kg/m2) was effective for buffering the effect of equipment operation on the mineral soil. Thus if cut to length systems are used and heavy slash is maintained on the skid trails, the extent of detrimental effects could be reduced. The same thesis noted that cut to length harvesting systems, which require that equipment stay on designated skid trails, create detrimental soil disturbance on about 10 percent of the harvested area. Han-Sup Han and others (2006) noted that logging when soils are drier than field moisture capacity reduced the amount of compaction associated with cut to length logging.

All mechanical slash piling or fuel reduction would be accomplished with excavators, or other machines that are light on the ground. This method reduces the aerial extent of detrimental soil impacts from the site preparation activities. Chippers mounted on tracked equipment similar to excavators would create soil effects similar to an excavator.

Summary. Both literature and local monitoring results indicates that, if commercial timber sales take place, we can meet the regional soil quality standards by using designated skid trails that occupy less than 15 percent of the harvest area. Additional protection of the soil resource would be afforded by operating ground based equipment when soils are dry; by operating in winter on snow or frozen soils; or by operating equipment on a dense slash mat. Cut to length harvesting also meets the regional soil quality standards as indicated by both literature and local monitoring.

Organic Matter and Nutrients

All of the proposed treatments are designed to reduce the amount of fuels and reduce the risk of wildfire. As a result the amount of organic matter and its associated nutrients would be reduced. The question is would enough organic matter be left on the site to insure soils promote the vigor and growth of the desired forest vegetation. Most units would have around 10 tons per acre of a mixture of coarse to fine woody material left on the units. This would include 1 to 3 tons in the < 3 inch size class and 7 to 9 tons in the > 3 inch size class. This falls within the reference by Graham et al. (1994) for these habitat types in Montana that recommends between 5 and 14 tons per acre. In those treatment units where coarse woody debris will be less than 5 tons per acre, there will still be 1 to 3 tons per acre of fine material (<3 inch size class). The reason for the departure is for fuel reduction purposes for facilities protection and for firefighter and public safety. All organic matter provides water and nutrients for soil organisms and plants, though the contribution of nutrients from large woody debris, in some forests, is relatively minor (Prescott and Laiho, 2002, p. 390). In all cases, the amount of material left on site would be more than that left by a severe wildfire.

In a study in northwestern Montana that looked at logging followed by slash burning, Jurgenson et al (1981) concluded there would be no long-term depletion of nitrogen reserves and that losses of nutrients associated with organic matter are temporary changes. The total amount of nutrients on a site would likely be reduced where large amounts of organic matter would be removed. However, the plant available nutrients (those released from organic matter) would increase because sun and moisture would be increased in the treated stands, conditions that speed the breakdown of the remaining organic matter and the release of nutrients (Harvey et al., 1994). After project implementation competition between trees would be reduced because fewer trees would remain on the sites. This situation could result in more available nutrients and water for the remaining trees (Powers et al., 2005).

Whole Tree Yarding.

Ground based timber harvests that utilize whole tree yarding have the highest risk of reducing organic matter and affecting nutrient content of the site. In whole tree yarding, the entire tree including the braches and needles, minus those that break off when the tree falls to the ground, are taken to the landing. At the landing, the branches and needles are trimmed off the tree and put into a pile. This process can remove a large amount of organic material and associated nutrients from the activity area. However, the effect on the ground and on productivity depends on the inherent productivity of the soil, how much organic matter is left behind and whether it is enough to provide what the next forest requires to grow and be healthy.

Harvey et al. (1994) state that it is most difficult to resolve the loss of nutrients on sites with high fire potential. One potential result of this proposed project would be to reduce the risk of wildland fire by reducing the amount of fuels within the activity areas and by increasing the spacing between the remaining trees. More nutrients and organic matter

would remain on all these sites after treatment than compared to a similar site burned by a severe wildfire.

All prescriptions would leave a portion of the existing stand on the site. The proposed treatments are described in detail in the Forest Vegetation section. Timber management that leaves trees on the ground also leaves nutrients on the site for sustaining the future forest.

Excavator Piling. Excavator piling may be used for some of the mechanical fuels reduction work. Thus, the amount of organic matter on the site would be reduced. However, a variety of all organic matter would remain on the site after project implementation.

Chipping. Chipping is an option for reducing the amount of fuels on some activity areas. Chipping is carried out by equipment similar to an excavator, thus would have similar effects on the soil. In addition, chipping leaves all the treated organic material on the soil surface where it contributes to the nutrient supply for the future forest.

Hand Treatments. Some units could be thinned by hand. In these same units, some organic matter would be put into small hand piles and burned. Because the hand piles are small, the amount of area disturbed by burning them would be less than 10 feet in diameter and they would burn with lower amounts of heat and smoke, compared to machine piled piles. The amount of nutrients lost during burning would be minor. The ash where the hand piles are burned would contain nutrients available to nearby vegetation.

The amount of heat generated by small hand piles is less than that created when large piles burn. As a result, the amount of nutrients that go up with the smoke would be minor. As discussed by DeBano, et al. (1999, p.112) the effect would not likely be adverse to soil productivity because nutrient replenishment mechanisms remain on the site. These mechanisms include the presence of nitrogen fixing organisms, both plant and microorganisms, organic matter that is left on the soil surface, and living vegetation on the site.

Vegetation and soil microorganisms remaining in the treated sites would use and store nutrients released from organic matter, preventing nutrients from leaching from the site. The amount of nutrients leached as a result of the proposed project would be less than the loss after wildland fires because of the presence of living trees, shrubs, grasses, and forbs left in the treatment units.

Summary. Most proposed units would retain adequate live trees per acre, that would retain a large amount of nutrients on site. In addition, most of the living forbs, grasses and shrubs would remain along with much of the material on the ground. All of the units would have an active microorganism-rich organic layer on the soil surface. Most units would also have an adequate mixture of coarse to fine woody material left on the units. In those treatment units where coarse woody debris will be less than 5 tons per acre, there

will still be 1 to 3 tons per acre of fine material (<3 inch size class). The reason for the departure is for fuel reduction purposes for facilities protection and for firefighter and public safety.

Soil Organisms

Because the amount of detrimental physical soil changes would be minimized, and because organic matter in various forms would remain on the proposed units, the effects to soil microorganisms would be minor. In fact, after fire, at least one study suggests soil micro-flora recover to levels greater than the original and recover rapidly (Jurgenson et al, 1977). Soil microorganisms are mobile. They can move from undisturbed sites to disturbed sites. Thus their loss is not permanent. A variety of organic matter will remain on all sites, including living trees and other forest vegetation. In addition, the organic layer on the soil surface will be retained over at least 85 percent of the area, providing habitat and nutrients for soil microorganisms.

Soil Erosion

Soil erosion would be unlikely to occur as a result of the hand treatments. If thinning slash is lopped and scattered it would add cover to the soil surface, reducing the risk of erosion. Burning hand piles would create small areas of disturbance that would be unlikely to erode because slopes are gentle and the disturbance is of small extent. If the hand piles are simply left on the site, there would be no risk of soil erosion.

Mechanical equipment operation would be most likely to cause soil erosion. Where there is a risk of soil erosion, it would be minimized by implementing the following management practices: reducing the area where equipment operates, locating landings on relatively flat ground that can be drained, locating skid trails on slopes less than 35 percent that have soils with a low or moderate erosion hazard and by using erosion control features such as water bars, planting vegetation, and placing slash on disturbed soils. Management activities that leave organic matter on the soil surface also reduce soil erosion. Using these management tools in the proposed project would minimize soil erosion. Detrimental effects caused by soil erosion are long term. The soil lost by erosion can take hundreds to thousands of years to re-form.

Mass Failures

Only unit 1, in the Benbow area, has a slightly higher risk of mass failure as a result of proposed management. Part of proposed treatment unit 1 (25% of the unit) is located in a TEUI draft Landtype unit that is mapped as Landflows. This appears to be relict feature; there is no evidence of recent mass failures within the project area. This suggests that the area has a low mass failure risk. Implementation of road best management practices (BMPs) associated with this project would reduce concentrations of road surface drainage, thereby reducing the risk of mass failures associated with road drainage. Location of landings and skid trails should be made with consultation of either the Forest Soil Scientist or Hydrologist. For all other units the proposed mechanized treatments are planned for a landscape with slopes generally less than 30 percent, which greatly reduces the risk of mass failures.

Duration of Direct and Indirect Effects
Displacement, the loss of topsoil, is a long term and perhaps a permanent loss of soil productivity. However, the management practices outlined in the design features would reduce the amount of displacement and all other detrimental impacts, to within the Region 1 guidelines.

Compaction lasts 10 to 70 years (Gonsior 1983, p. 13 - 16). Monitoring of 10-20 year old timber sales on the Forest showed very few areas having compaction that is considered detrimental soil disturbance, indicating recovery of the compacted soils has occurred.

Reductions in organic matter content recover quickly as vegetation grows. Organic debris accumulates on the surface and roots grow and are decomposed in the soil. These organic materials break down and release nutrients and improve the quality of the soil by improving its structure and reducing compaction and other detrimental soil disturbances. Loss of organic matter is a short term change lasting about 10 years once vegetation returns to the soil.

Soil erosion would be controlled through the use of erosion control measures. In addition, bare soils would either be vegetated with native seed or would naturally recover as vegetation returns to the disturbed sites. Any erosion that occurs would be short lived, most likely occurring during the time between the soil disturbance and the implementation of erosion control measures.

Temporary Road Construction
The proposed action would construct approximately 1.7 miles of temporary roads. These roads are needed to access unit 60 in the Benbow area. Approximately 0.9 miles of the temporary road will be on private land and 0.8 miles of temporary road will be on National Forest System Lands. It is difficult to assess the amount of detrimental disturbance associated with temporary roads. All temporary roads will be ripped, reseeded, and re-contoured, if necessary. Restoration of roads and trails has a high degree of success. It is estimated that around one-third to one-quarter the original disturbance will be detrimental, less than one acre. The disturbance to unit 60 accessed by temporary roads should still be within the Regional Soil Quality Guidelines.

Cumulative Effects
Cumulative effects occur when past present or foreseeable activities overlap in both time and space with the proposed activities. Thus, cumulative effects are limited to the activity area where the proposed activities would occur. In other words, cumulative effects occur only where proposed activities would occur where previous management has affected soil conditions. Activities outside of the locations of proposed management are not subject to cumulative effects because they do not overlap spatially with the lands being proposed for management in the Beartooth Front Storm Damage Clean-up And Fuels Reduction Project. Soil effects do not extend off of the piece of ground where they occur.

The risks of cumulative effects were assessed within each proposed activity area. Cumulative effects consist of the impacts from all past, present, future and proposed activities that overlap in time and space with the proposed project.

Past Actions and Their Effects on Current Conditions.
None of the proposed harvest units had evidence of past commercial harvest activities, other than firewood and post and pole cutting. Firewood cutting and post and pole harvest along roads has had minimal effects on soil productivity because it is carried out by hand and the fine branches and needles are left in the woods.

Almost all proposed treatment units have had some past disturbance, through grazing (only in the Benbow area), firewood gathering, camping, and other recreational activities. Past recreation activities include dispersed camping, ATV use, hunting, and fishing. ATV use is restricted to existing trails. Dispersed camping, in some cases, results in reduced vegetation, increased compaction, increased runoff, and accelerated erosion. These occur in some areas but are not widespread throughout the project area.

Contrasting Effects of Proposed Action with Past Actions.
The estimated level of detrimental disturbance from this proposed project is around 10% to 11% or less, and is less than has occurred as a result of commercial timber harvest activities in the past. During the past two decades, the level of concern for maintaining soil productivity has increased and along with this has come implementation of management practices that better protect the soil. These changes include the use of excavators instead of dozers for mechanical site preparation; cut to length yarding systems; use of designated skid trails; and operating when soils are dry or when winter conditions would protect soil productivity.

In addition, timber sales are audited for compliance with BMPs and are monitored to see that design features that reduce soil effects are implemented. Both of these practices produce better results than in the past.

Log landings, proposed skid trails, and roads should use existing ATV trails and dispersed camping sites and access where possible. The disturbance to these areas will be less than if creating new disturbance.

Effects of Ongoing and Reasonably Foreseeable Activities.
In the Benbow area, the continuation of livestock grazing activities will overlap with the proposed action in both time and space. Grazing activities could potentially contribute to the effects, however, the existing condition indicates it is not detrimental. All areas will continue to be used for dispersed camping, ATV riding, hiking, skiing, and hunting. Effective rehabilitation of temporary roads and skid trails will need to occur to limit future disturbance by these activities. The Beartooth Travel Management Plan outlines the dispersed recreation sites that will be reclaimed for water quality concerns. All other dispersed camping sites within 300 feet of the roads and motorized trails will remain available for dispersed camping activity.

Combined Effects from Past, Proposed, Ongoing and Foreseeable Activities
Cumulative effects on soils are the combination of the existing detrimental disturbance from past activities combined with the estimated disturbance that would result from the proposed project. The units with the highest risk of exceeding the regional soil standards are those that had past activities and still have some detrimental soils disturbance. Monitoring would emphasize the proposed activities that would remove merchantable trees with mechanized equipment from units with detrimental soil disturbance from past activity. If the cumulative effects exceed soil quality standards, then restoration would occur to move those units towards improved conditions.

Restoration activities to improve soil conditions would include lightly ripping heavily used skid trails and landings. The goal would be to reduce soil compaction and meet the direction provided in Region 1 Supplement 2500-99-1 (See Regulatory Framework and Consistency at the end of this section). Several studies discuss the effectiveness of ripping as a soil restoration activity. Studies cited by Froehlich and McNabb (1983) showed up to 39 percent improved seedling survival and growth after tilling compacted soils. The same study showed height growth gains of 8 to 73 percent. A publication by Dick, et al. (1988) found rehabilitation treatments of subsoiling (tilling) restored biological processes that were reduced by soil compaction. In general, tilling or scarifying a compacted soil improves productivity by reducing the resistance of soil to root penetration, and providing improved soil drainage and aeration to enhance seedling establishment and tree growth (Bulmer 1998, p 10 and 13) and improve the environment for soil organisms. The goal of soil restoration is to set the stage for the soil to begin the recovery process. Soil restoration is not an immediate result of ripping, planting, or any other activity.

Regulatory Framework And Consistency
The existing condition indicates there is little detrimental soil disturbance throughout the project area. The soil analysis indicates that all alternatives and all activities proposed by the alternatives would meet the Region 1 Soil Quality Standards through the implementation of management practices outlined in Design Criteria and restoration of landings and heavily used skid trails, if needed, to reduce the total amount of detrimental soil impacts. All Forest Plan management direction would be met by the proposed action.

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Table 1: Project Design Features		
Project Design Feature (By Resource Area or Activity)	**Description of Project Design Feature**	**Units/Alternative to which Project Design Features Apply**
Watershed/Soils		
WS-1	Utilize applicable Forest Plan standards and guidelines, Montana Streamside Management Zone BMP's, Montana Forestry BMP's and the Soil and Water Conservation Practices BMP's. Comply with Montana Stream Protection Act and obtain appropriate permits where necessary.	
WS-2	Avoid ephemeral swales with temporary road construction. Cross ephemeral swales at right angles where crossings are needed. Minimize the construction of temporary roads within ephemeral swale areas.	
WS-3	All temporary roads shall be constructed to minimize cuts and fills.	
WS-4	Decommission all temporary roads and skid trails as follows. • All temporary road segments would be fully recontoured. • Slash, cull logs, or rootwads should be used where available to prevent re-use of temporary roads and skid trails. • All disturbed areas shall be seeded with an approved seed mix.	
WS-5	Coarse Woody Material should be left at a rate of approximately 7-9 tons/acre to help the recovery of long-term soil productivity	
WS-6	Areas of concentrated soil disturbance such as temporary roads and landings would be scarified where compaction exists and seeded after harvest activities are complete- but prior to the following winter season. Erosion control and drainage measures would be applied within two days of the completion of unit harvest activities.	
WS-7	Locate skid trails on existing jeep trails or old unclassified roads where available. Locate skid trails to avoid concentrating runoff and provide breaks in grade. Locate skid trails and landings away from natural drainage systems and divert runoff to stable areas.	