SOIL QUALITY

Public and internal comments focused on one issue in regard to the potential effects of travel management on soil quality.

EFFECTS ON SOIL QUALITY FROM THE EXISTING ROAD AND TRAIL SYSTEM UNDER CURRENT LEVELS OF MAINTENANCE.

Soil quality concerns increase when the design and location of roads and trails are not adequate, when roads and trails cross sensitive soils and when maintenance levels are not adequate.

1. EXISTING CONDITION

a. Natural Characteristics and Past Events and Conditions

The project area falls in the Little Belt/Snowy/Judith Mountains (M332Db) and Crazy Mountains (M332Dc) Subsections (Nesser et al. 1997). The Little Belt/Snowy/Judith Mountains Subsection is described as uplifted mountains that formed predominantly in limestone, sandstone and shale. Igneous rocks intrude into the uplifted limestone and are exposed at higher elevations. Elevations range from 3,500 to 9,200 feet. Drainage density is moderate. Mean annual precipitation ranges from 13 to 42 inches with 40 to 60 percent falling as snow. The Crazy Mountains Subsection is described as uplifted mountains that formed in sandstone and mudstone with a central core of igneous intrusive rock. Elevations range from 6,000 to 11,000 feet. Drainage density is moderate. Mean annual precipitation ranges from 15 to 60 inches with nearly 70 percent falling as snow.

Land type mapping of the soils analysis area, Forest Service portions of the Little Belt, Castle and northern Crazy Mountain Ranges, follows Holdorf (1981). A summary of land types with sensitive soils and their extent are found in Table III-57. Soils of the analysis area are a result of a number of factors including: landforms, parent material, climate, vegetation and time. A variety of these factors are found in the analysis area resulting in a variety of soils and soil characteristics. Sensitive soils are: 1) soils with high clay contents in the subsoil layers that are prone to mass failure when cleared of vegetation or when cut by roads or trails; 2) thin, weakly developed soils on steep slopes that easily erode and are difficult to stabilize; 3) soils formed over shales that readily weather to clay and are unstable when wet; and 4) soils of floodplains or soils with shallow water tables that have easily damaged structure. These soils have physical characteristics that may affect travel or be affected by travel routes. See Map 8 for the extent of sensitive soils in the soils analysis area.

Table III-57.
Land Types with Sensitive Soils and Their Extent in the Analysis Area (Holdorf 1981)

Land Type	Limitation/ Hazard	Acres (FS)	Landforms	Slope Class (percent)	Parent Material Geology
14C	Severe slump potential	21,095	Rotational slumps and mudflows	25-40	Shale
14D	Moderate slump hazard, severe road mass failure hazard	9,651	Rotational slumps and mudflows	25-40	Shale
17	Moderate erosion hazard on compacted soils	4,902	Ridges and valley sideslopes	10-25	Shale
17A	Moderate erosion hazard on compacted soils	4,152	Steep, warm aspect slopes	40-60	Sandstone and shale
19	Severe erosion potential for subsoils	18,970	Steep valley sideslopes	25-40	Granite and gneiss
20A	Moderate mass failure potential	7,864	Colluvial basins or toeslopes	25-40	Undifferentiated
20F	Severe erosion potential on compacted soils	23,821	Steep valley slopes	25-60	Sandstone or granite
23B	Severe erosion potential for subsoils	9,052	Steep upper valley sideslopes	25-40	Limestone, slowly permeable
26	Severe erosion potential on compacted soils	7,488	Ridgetops	0-10	Sandstone
27	Moderate erosion potential on compacted subsoils	28,467	Ridges and upper slopes	10-40	Granite and shale
27A	Moderate erosion potential on compacted subsoils	10,983	Ridges and upper slopes	10-40	Granite and shale
42	Moderate mass failure potential	8,247	Benchy lower valley slopes	10-40	Shale
43	Moderate mass failure potential	1,097	Valley sideslopes	10-40	Basalt
43A	Moderate slump hazard	1,146	Ridgetops	10-40	Basalt
44	Severe erosion hazard on compacted soils, moderate road slump hazard	1,337	Benchy lower valley slopes	10-25	Clay shale
52	Severe erosion hazard on compacted soils	10,606	Hilly valley bottoms	10-40	Shale
52A	Severe erosion hazard on compacted soils	5,384	Hilly valley bottoms	10-25	Shale
59	Severe erosion hazard on compacted soils	7,271	Upland flats and basins	10-25	Shale
59A	Severe erosion hazard on compacted soils	1,944	Benchy lower valley slopes	25-40	Shale

Land Type	Limitation/ Hazard	Acres (FS)	Landforms	Slope Class (percent)	Parent Material Geology
63A	Severe erosion hazard on compacted soils	241	Steep valley sideslopes	25-40	Gneiss
66	Moderate erosion hazard	7,464	Steep valley sideslopes	25-40	Shale
68	Severe erosion hazard on compacted soils	2,222	Benchy lower valley slopes	10-25	Clay shale
110	Severe erosion hazard on compacted soils	3,075	Lower valley slopes	10-25	Shale
159	Severe erosion hazard on compacted soils	2,833	Ridges and upper slopes	10-25	Shale
200	Wet	6,597	Well drained floodplains	0-10	Undifferentiated
201	Wet	751	Wetland	0-10	Undifferentiated
	Total	**206,660**			

Vegetation is largely defined by a combination of climate and soils. However, other natural agents of fire or insects and disease may alter vegetative composition and ground cover. A number of wildfires have burned in the analysis area since 1985. Some of them, such as those in 2001 and 2003 had severely burned areas that resulted in sediment reaching area streams. Table III-58 below summarizes recent wildfires on Forest Service lands that grew to more than ten acres.

Table III-58. Summary of Forest Fires since 1985

Year of Fire	Name	Acres	Year of Fire	Name	Acres
1985	Deep Creek	33	1999	Lucy Park	12
1985	Newlan Creek	51	1999	Spring Creek	169
1985	Sand Point	10,320	2000	Antelope	24
1985	Smokey Mtn	20	2000	High Springs	68
1988	Castle Creek	51	2000	Lost Fork Ridge	1,403
1988	Iron Claim	1,396	2000	McGuire Ranch	25
1988	Lick Creek	985	2000	Stud Horse	13
1988	Spring Creek	33	2001	Lost Fork	2,197
1990	Turkey	4,581	2001	Monarch	1,684
1991	Forty Creek	27	2002	Cooper Creek	13
1991	Harrison Creek	452	2003	Ant Park	2,107
1991	Logging Creek	44	2003	Burnt Ridge	52
1991	Sawmill	40	2003	Iron Butte	152
1991	South Fork	16	2003	Long Mountain	147
1991	Willow Park	60	2003	Sheep Creek	11
1994	Forest lake/Smith Ck	763	2004	Forty Creek	12
1996	Coyote	3,421	**Total**		**30,512**
1998	Tollgate	130			

b. Human Influences

The most important human activities that have affected soils resources are livestock grazing, timber harvest, and roads and trails. Grazing allotments occur throughout the drainages but because of steep terrain, grazing pressure is concentrated generally in the valleys, meadows, and flat benches. Effects of livestock grazing on uplands are usually restricted to small concentrated areas where livestock bed, loaf under shade, water at developments, obtain salt, and trail along fence lines and driveways. The soils of these areas are compacted and have increased wind and water erosion due to reduced vegetative cover and increased bare ground (Clary et al. 2000). Grazing by cattle on riparian zone soils increases bare ground, increases erosion by water, ice and wind, decreases the litter layer, increases compaction, decreases infiltration and decreases fertility (Belsky et al. 1999; Wheeler et al. 2002). Table III-59 below summarizes some recently documented conditions from range analyses in the soils analysis area.

Table III-59.
Summary of Recent Range Analysis Data

Range Analysis Area	Percent of Suitable Range Acres in High or PNC Ecological Status	Miles of Streams Accessible by Livestock in Non-Functioning or Functioning-At-Risk Condition from Livestock Grazing
Sheep Creek Range Analysis (2004)	Approximately 71% of 20,049 acres	40% of 167 miles = 66.8 miles
Musselshell Range Analysis (2002)	Approximately 54% of 18,840 acres	29% of 71 miles = 20.6 miles
Belt Creek Range Analysis (1998)	Approximately 55.9% of 5,450 acres	16% of 79 miles = 12.6 miles
Castle Mountains Range Analysis (1997)	Approximately 63% of 18,309 acres	61% of 41.7 miles = 25.3 miles(1)

(1) Earlier methods of assessing stream condition used compared to other studies. 61% of livestock accessible perennial streams found to be in fair or poor condition primarily based on hydrologic conditions without assigning a cause.

Timber harvest has occurred throughout the soils analysis area. Many Forest roads were built or upgraded to reach timber sales. Detrimental impacts from timber harvest on soils usually occur as part of yarding logs, building and using skid trails and landings, and slash disposal with fire. These activities expose mineral soil and have the potential to compact, displace, burn or puddle soils (Holdorf 1981; Clayton 1990; Elliot et al., 1999). Exposed soils are susceptible to erosion from runoff (Holdorf 1981; Clayton 1990; USDA 1996). A summary of past timber harvest in the soils analysis area by decade is found in Table III-60.

Table III-60. Summary of Past Forest Service Timber Harvest Acres by Decade in Soils Analysis Area

Treatment	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2005
Commercial Thinning		209	649	694	958	344
Improvement Cut				88	83	
Liberation Cut				29	191	
Overstory Removal	58	117	32	57		
Clearcut	5681	15037	9594	4676	8164	1647
Sanitation Salvage	209	38	692	267	1915	174
Seed-tree Cut	178		42	242	944	348
Shelterwood Cut	148	72	701	1421	2108	1309
Single tree Selection Cut	223		7	39	125	
Totals	**6,497**	**15,437**	**11,716**	**7,513**	**14,488**	**3,822**

As described above, certain soils and land types are identified as being "Sensitive" (Holdorf 1981). These soils have physical characteristics that may affect travel or be affected by travel routes. Miles of roads and trails on Forest Service lands that cross land types with sensitive soils are summarized below in Table III-61.

Table III-61. Miles of Roads and Trails Crossing Land Types with Sensitive Soils by Road Class (Existing Condition) on Forest Service Lands in Soils Analysis Area

Map Coding-Road and Trail Class	Roads	Trails
1—Closed yearlong to all	48.0	10.8
2—Open to snowmobiles	3.0	5.9
3—Restricted snowmobile	50.7	7.0
4, 9, 25.2—Restricted snowmobile and motorcycle	12.0	39.8
5, 6, 24.1—Restricted ATV, motorcycle, and snowmobile	8.3	13.0
7—Open to ATV, motorcycle and snowmobile	2.4	45.6
8—Open motorcycle and snowmobile	0.6	72.7
18, 22.1—Restricted ATV and motorcycle	0	3.9
20—Open to all	414.9	4.1
21, 22, 23, 25, 27, 29—All motorized restricted	87.9	0.2
50--Administrative	9.0	
51--Undefined	0.1	
Totals	**636.9**	**203**

Road and trail maintenance is one monitoring tool of soil conditions. Approximately 3-9 percent of primarily the most traveled roads on Forest Service lands have been maintained each year in the 2000-2005 period. Road maintenance measures include grading, restoring drainage, some additional new drainage features, and some new gravel surfacing.

Approximately 4-12 percent of all trails receive some maintenance each year (Metrione 2006; Butts 2006). Trail maintenance measures consist of clearing, water bar maintenance, repair and cleaning ditches, and limited new drainage feature construction. Some new construction, reconstruction, or rerouting and restoration of abandoned segments occurs each year dependent upon funding. Erosion control is focused on with an emphasis on routing water off trails.

Forest records show soils concerns of vegetation removal, rutting and erosion from unauthorized travel in the Big Baldy, Oti Park, Haymaker Creek, Newlan Creek, Dry Fork and Jellison Place areas. Soils concerns from inadequate maintenance or use levels that exceed the design of trails are known on Trails 731, 732 and 736 in the Hoover/Bender Creeks area, Trail 344 to the Taylor Hills area, Trail 718 to Elk Peak and high on Trail 304 along Pilgrim Creek. Soils concerns from inadequate maintenance or use levels that exceed the design of roads are known on Forest Road (FR) 211 in the West Checkerboard Creek area, FR 268 in the Monument Peak/Daisy Springs area, FR 3425 along Sheep Creek, FR 251 in the Teepee Butte/Yogo Peak area, FR 613 along Ruby Creek/Henn Gulch, FR 267 along Jefferson Creek, FR 6414 along Adams Creek and FR 487 southeast of Kings Hill. This listing is not complete, but gives examples of known areas of concern.

c. Applicable Laws, Regulations and Policy

Desired conditions are based on the applicable laws, regulations and policy, which include:

- Forest and Rangeland Renewable Resource Planning Act of 1974 and National Forest Management Act of 1976
- Multiple Use Sustained Yield Act of 1960
- Executive Order 11644, Use of Off-Road Vehicles on the Public Lands (February 8, 1972), Amended by Executive Order 11989, Off-road Vehicles on Public Lands (May 25, 1977).
- Lewis and Clark National Forest Plan
- United States Forest Service Region 1/Region 4 Soil and Water Conservation Practices Handbook

More complete discussion of applicable Laws, Regulations and Policy are found in the project file, Appendix A, Montana Water Quality law and Appendix G, Best Management Practices.

A critical component of the Desired Condition is meeting Forest Plan direction. An important Management Standard in the Lewis and Clark National Forest Plan for Soil, Water and Air Protection (F3) is: 1) Require application of Best Management Practices to project activities to ensure meeting or exceeding State water quality standards. Soil and Water Conservation Practices (SWCPs) (Forest Service 1995) are the equivalent of Best Management Practices (BMPs). Soil and Water Conservation Practices 15.21, Maintenance of Roads, describes the minimum level of maintenance to be: “Provide the basic custodial care required to protect the road investment and to insure that damage to adjacent lands and resources is held to a minimum.”

As described above, the current level of road and trail maintenance is largely based on funding and Forest priority. Only 3-9 percent of the roads on Forest Service lands in the

analysis area have been maintained yearly since 2000. The roads that receive maintenance are among the most improved and also thought to be the most used roads in the analysis area. These routes include forest road (FR) 67 Lick Creek Road, FR 119 Sheep Creek Road, FR 120 Dry Fork Belt Creek Road, FR 211 Four Mile Road, FR 266 Yogo Creek Road, FR 274 Spring Creek Road, FR 487 Memorial Way, FR 586 Williams Park Road, FR 839 Divide Road, FR 1036 Allen Gulch Road and FR 6511 Belt Park Connector. Approximately 4-12 percent of all trails receive some maintenance each year. The trail maintenance focuses on the most developed trails. From Table III-61, Miles of Roads and Trails Crossing Sensitive Soils by Road Class, roads cross approximately 637 miles of land types with sensitive soils, and 203 miles of land types with sensitive soils are crossed by trails in the analysis area. The risk of soil impacts adjacent to roads and trails, and the risk to water quality of perennial streams from roads and trails that are currently receiving no or little maintenance are moderate or greater. As will be shown in the Analysis of Action Alternatives below, the miles of roads and trails crossing sensitive soils change little with the Action Alternatives.

The current levels of road and trail maintenance will hold or decrease in the future (Gavrisheff 2006). This situation applies to the Existing Condition, or the No Action Alternative, as well as all the Action Alternatives. Meeting Forest Plan direction with the No Action Alternative or the Action Alternatives based on current levels of maintenance is doubtful.

2. ENVIRONMENTAL CONSEQUENCES

Watersheds, undisturbed by human influences, are not static systems. Deep snowpacks and heavy spring rains can cause flooding. Wildfire, wind, or insect and disease mortality can drastically alter the vegetative composition of a watershed. Depending on the extent of mortality and rate of stand decomposition, impacts to soils as well as stream systems can be significant. However, watersheds left undisturbed after natural events can and do recover. These natural disturbances occur infrequently, which allows for significant and generally rapid recovery of erosional and hydrologic processes prior to the next major disturbance.

Road and trail systems have less of an impact to analysis area soils than natural disturbances such as wildfire. Construction and use of roads and trails are chronic sources of erosion and sediment to the analysis area watersheds.

a. Alternative 1—No Action Alternative

Construction and use of roads and trails by different means of travel can cause detrimental soil displacement, compaction, erosion, and loss of soil and hydrologic functioning. These detrimental soil impacts tend to be greater on sensitive soils. These detrimental impacts also tend to increase with greater levels of use and on routes lacking engineering design. Regular maintenance of roads and trails can help minimize impacts, especially erosion. Identifying the miles of roads and trails that cross sensitive soils, reviewing road and trail maintenance levels, and attempting to identify roads and trails with increased risk of soil concerns based on road location and design are focused on.

1. Direct and Indirect Effects

Natural disturbance events will continue to influence erosional and hydrologic processes within the watersheds of the analysis area. Given the current vegetative conditions, drought and associated fuel accumulations, there is potential for wildfires to occur that may be outside the range of conditions (intensity and duration) that have occurred over the last few hundred years. Depending on the intensity and area burned, accelerated soil erosion is possible, particularly where hydrophobic soils may be formed on moderately steep or steep slopes of landforms that have had stream erosion as a primary process in their formation (Wondzell and King 2003). Soil erosion could be expected, especially during years of average or higher precipitation/runoff conditions. Soils will stabilize as vegetative recovery progresses.

Roads and trails affect the soil resource in a number of ways. The building and construction of roads and trails requires vegetation removal, soil disturbance, and slope contouring. These actions disrupt the layering of soils and change the physical properties of bulk density, infiltration rates, water holding capacities, nutrient concentrations, and gas exchange rates. Established road and trail surfaces are essentially removed from the productive soils base (Gucinski et al. 2001). Roads and trails can intercept surface flows, concentrating runoff and directing flows and erosion toward streams (Wemple and Jones 2003). Roads and trails built across sensitive sols with a high risk of mass movement undermine upper slopes and increase the risk of soil movement and mass failure (Gucinski et al. 2001). Roads and trails built across shallow, weakly developed sensitive soils on steep slopes, especially at high elevations, are prone to erosion because these soils are difficult to stabilize. Segments of roads and trails may be jumbled and carried downslope if built on sensitive soils and landforms prone to slumping. Roads and trails built on floodplains may be severely eroded or removed during major flooding events. Roads and trails built on soils with shallow water tables may severely rut and lose structure due to low bearing strength.

Most primary roads have been engineered and designed to limit erosion and sedimentation. Lack of maintenance leads to: rutting and loss of surfacing if present, increased erosion, and sedimentation (Seyedbagheri 1996; Swift 1984; Foltz and Burroughs 1990). Primitive two-track roads have little engineering and are prone to rutting and erosion if not maintained regularly. Trails have less impact but the travel way is usually bare and compacted with the risk of accelerated erosion and sedimentation.

Soil impacts from roads and trails tend to be more severe at high elevations due to higher precipitation rates, an extended period of snowmelt resulting in muddy soils, more severe freeze/thaw cycles causing more loose soil and increased exposure to wind erosion (Leung and Marion 1996).

Road and trail impacts to soils continue once established, since the soil comprising the travel way is subject to continuing erosional forces of rainfall, running water, wind, freeze/thaw cycles, gravity, and traffic (Leung and Marion 1996; Switalski et al. 2004; Summer 1986). Soil impacts are lessened or removed with restoration of roads and trails and establishment of vegetation effective in controlling erosion.

Soil impacts from roads and trails tend to increase with increased use, with some means of travel and on steep slopes. Studies in southwest Montana and northwest Wyoming (Dale and

Weaver 1974; Weaver and Dale 1978; Wilson and Seney 1994) have shown that on gentle slopes hiker and horse trails tend to be wider in meadows than in forests. Trail widths of horse trails in meadows were between 40 and 80 inches wide with 3000 or more uses per year. Horse trails on gentle slopes were nearly twice as deep as hiker trails in forested sites and 50 percent deeper in meadows. On sloping sites trail widths and depths increase over gentler slopes. Researchers found on meadow trails that motorcycle damage was greatest when traffic was upslope while horse and foot traffic was most damaging when the traffic was downhill. Weaver and Dale (1978) concluded: "Damage generally increased from hiker to motorcycle to horse in our study; if ridden at less conservative speeds, i.e. greater than 20 km/h, motorcycles might be more damaging than horses."

Meyer (2002) evaluated OHV (ATV) trails in Alaska and found that problems arise when these vehicles use trails that were not designed for them. "Because of the unplanned nature of OHV (ATV) trails, many of them cross soils and sites poorly suited for the level of use occurring today." Findings of the three state Off-Highway Vehicle EIS (USDA and USDI 2001) that included Montana were somewhat similar to the studies above. "The degree of disturbance and compaction varies by site and would correspond to the type of driver, vehicle, tire tread, tire width, weight, angle of force to the soil and vegetative cover. Usually, compaction increases as tire size decreases, or vehicle weight increases and forces such as turning, accelerating or braking are added." Further, sheet or rill erosion "would be most common on poorly designed or maintained roads and trails during periods of high soil moisture, rainfall, and/or melting snow."

The portion of the analysis area road and trail system that will be focused on is that part where roads and trails cross sensitive soils, on roads and trails that are receiving little maintenance and where roads and trails lack engineering designs or are located in difficult terrain. Sensitive soils again are: 1) soils with high clay contents in the subsoil layers that are prone to mass failure when cleared of vegetation or when cut by roads and trails; 2) thin, weakly developed soils on steep slopes that easily erode and are difficult to stabilize; 3) soils formed over shales that readily weather to clay and are unstable when wet; 4) soils of floodplains or soils with shallow water tables that have easily damaged structure. These are the areas of greatest likely hood of finding soils that have physical characteristics that may affect travel or be affected by travel routes. Table III-62 below provides a breakdown of road and trail use for the existing situation and also the action alternatives.

Table III-62. Miles of Roads and Trails Crossing Land Types with Sensitive Soils by Alternative and Travel Class on Forest Service Lands in the Soils Analysis Area

Map Coding– Road and Trail Class	Summer Alt. 1		Summer Alt. 3		Summer Alt. 4		Summer Alt. 5	
	Roads	Trails	Roads	Trails	Roads	Trails	Roads	Trails
1 -- Closed yearlong to all	48.0	10.8	50	21.3	65.3	134.5	59.8	66.7
2 -- Open to snowmobiles	3.0	5.9	1.3		1.3		2.5	1.8
3 -- Restricted snowmobile	50.7	7.0	28.8	0.7	33.9	0.7	27.3	5.1
4, 9, 15, 25.2, 39 - Restricted snowmobile and motorcycle	12.0	39.8	0.9	41.7	1.3	16	0.6	28.9
5, 6, 24.1, 40 – Restricted ATV, motorcycle, and snowmobile	8.3	13.0	20.8	4	6.6	2.8	15.1	11.9

Map Coding– Road and Trail Class	Summer Alt. 1		Summer Alt. 3		Summer Alt. 4		Summer Alt. 5	
	Roads	Trails	Roads	Trails	Roads	Trails	Roads	Trails
7 – Open to ATV, motorcycle and snowmobile	2.4	45.6	9	82.1	3	38.1	2.8	39.3
8, 38 – Open motorcycle and snowmobile	0.6	72.7	0.5	58.3	0.5	7.5	0	19.8
11, 13, 18, 22.1, 41 – Restricted ATV and motorcycle	0	3.9	0	15.3	11.8	0.8	0	5.9
20 -- Open to all	414.9	4.1	277.3	0.9	272.3	2.7	244.3	0
16, 21, 22, 23, 24, 25, 27, 29 -- All motorized restricted	87.9	0.2	70.2	0	66	0	98.9	12.7
50-- Administrative	9.0	0	9.0	0	9.0	0	9.0	0
51-- Undefined	0.1	0	144.2	15.3	0	0	161.1	28.3
Totals	**636.9**	**203**	**612**	**227.8**	**471.0**	**203.1**	**621.3**	**220.4**

An important point relevant to Table III-62 is the totals are calculated as if effective restoration of closed and decommissioned roads and trails, both system and undefined, had occurred. Restoration of soil and hydrologic functioning of these features would be years away. Exiting roads and trails would continue to be removed from the productive soils base and could continue to be a source of erosion and sediment until they are restored. Site specific restoration methods have not been developed for closed roads and trails at this time. Road closure methods could consist of a range of measures from a gated closure to a more effective restoration consisting of relieving compaction, recontouring, draining, grading and seeding (Switalski et al. 2004). The summer portion of Alternative 2 was not analyzed separately since much of it was analyzed in other alternatives.

Soil quality concerns increase when the design and location of roads and trails are not adequate. Roads and trails with continuous, steep gradients are troublesome and costly to build and maintain with respect to soils (Gucinski et al. 2001). Roads and trails on steep grades typically require a wider disturbance width compared to routes on gentler grades to provide for stable large cuts and fills. Specialized equipment may be needed to build routes with large cuts and fills. An exception would be if the route follows a ridge top. Steep routes on ridge tops and sides slopes require closely spaced water handling devices to minimize the upbroken slope lengths where sheet erosion, rilling and gullying are concerns. Out sloping travel surfaces, closely spaced water bars or rolling dips and ditches between cut slopes and travel surfaces with regular cross drains are techniques often used to control runoff on steep routes. Stabilizing large cuts and fills and maintaining effective water controlling devices are critical to minimize erosion. Steep road and trail routes that cross sensitive soils can be even more challenging to stabilize and maintain (Gucinski et al. 2001). Steep road and trail routes lacking engineering design and maintenance that cross sensitive soils may be the most troublesome scenario with respect to minimizing detrimental impacts to soils (Gucinski et al. 2001; Forman et al. 2003). Sheet erosion, rilling, gullying, braided routes and mass wasting are commonly seen concerns.

A single index of measure that would encompass most of the soils related concerns with road and trail routes that lack adequate design and location is difficult to pin down. One useful measure is a sustained route gradient of 15 percent or more for a route segment of one mile or more in length. With the current level of maintenance these parameters are thought to

highlight erosion and stability concerns. A summary of this information is found in Table III-63 below. Map 15 shows the extent of existing road and trail segments with gradients over 15 percent and lengths exceeding 1 mile.

Table III-63.
Summary Table of Segments of Roads and Trails with Grades Over 15% and Lengths Exceeding 1 Mile on Forest Service Lands in the Soils Analysis Area

Alternative	Total Miles of Roads (Approximate)	Total Miles of Trails (Approximate)	Miles of Roads with Segments Steeper than 15% and Lengths Greater than 1 Mile	Miles of Trails with Segments Steeper than 15% and Lengths Greater than 1 Mile
1	1891	707	687 (36%)	503 (71%)
3	1788	810	618 (35%)	565 (70%)
4	1379	691	583 (42%)	468 (68%)
5	1816	831	641 (35%)	534 (64%)

Again, the totals are calculated as if effective restoration of closed routes had occurred. Effective restoration of closed routes in the different alternatives could be years away. Again, the summer portion of Alternative 2 was not analyzed separately since much of it was analyzed in other alternatives.

2. Cumulative Effects (Alt. 1)

The following apply from the list of Cumulative Effects for the project.

Wildfire could occur in much of the analysis area. The effects of stand replacing fire would be compounded by existing roads. Roads can increase surface and subsurface drainage efficiency, routing upslope waters to natural channels at higher rates, increasing erosion. The effects are expected to be higher with a high intensity burn over a large area on moderately steep or steeper slopes and where road densities are higher.

Prescribed fire could also occur in much of the analysis area. Prescribed fire as a tool for managing vegetation can cause detrimental soil impacts when severities are too high. Severe burning can consume duff layers and cause physical damage to the surface mineral layers of soil, especially timbered soils. Some plant nutrients stored in the burned material are converted to a gaseous state and lost from the site by burning. Nitrogen and sulphur are especially susceptible (Harvey et al. 1994). Fires may increase soil pH which directly effects availability of many nutrients. Endo- and ectomycorrizae are particularly sensitive to soil heating by fire because they are concentrated in the organic and upper mineral soil layers (Keane et al. 2002). Fires can also cause formation of water repellent layers in soils that impede infiltration and can cause massive erosion (Keane et al. 2002). Projects that could be implemented in the next 5 years are found in the Monarch/Neihart area (approximately 650 acres of mechanical fuels treatment with prescribed burning in units along US Highway 89), Ettien Ridge area (approximately 1650 acres of prescribed fire with approximately 680 acres of included timber harvest), Dry Fork of Belt Creek (approximately 2570 acres of burning with approximately 560 acres of timber harvest, 4.9 miles of road reconstruction, 1.7 miles of new road and nearly 20 miles of road decommissioning), Forest Green/Allen Gulch

(approximately 160 acres of prescribed burning and 140 acres of timber harvest with less than ¼ mile of temporary road construction), Mass/Geis Creeks area (yet to be determined combination of timber harvest and prescribed burning) and smaller prescribed burn units around Forest administrative sites, summer homes, radio repeater sites, campgrounds helispots and weather stations on the Musselshell Ranger District (units and areas yet to be determined). Through project design and application of Soil and Water Conservation Practices (USDA Forest Service 1995) the detrimental impacts to soils would be minimized.

Timber harvest in the analysis area has been widespread and ongoing. Table III-60 summarizes the acres impacted since 1950. Soil impacts usually occur as part of yarding logs, building and using skidtrails and landings, and slash disposal with fire. These activities expose mineral soil and have the potential to compact, displace, burn or puddle soils (Holdorf 1981; Clayton 1990; Elliot et al., 1999). Exposed soils are susceptible to erosion from runoff (Holdorf 1981; Clayton 1990; USDA 1996). Additional timber harvest is planned for Whitetail Salvage (approximately 65 acres with less than .25 mile of temporary road construction near Whitetail Creek on the Musselshell District) and Newlan Bugs Salvage (approximately 350 acres of harvest, construction of 1.4 miles of temporary road and rehabilitation/decommissioning of approximately 1.9 miles of road along forest Road 830 as it follows Newlan Creek). Similar to the prescribed burning and timber harvest projects above, project design and application of Soil and Water Conservation Practices (USDA Forest Service 1995) are important for minimizing impacts to soils.

Livestock grazing impacts to soils and water resources as described in the Existing Condition are expected to continue. Full implementation of Sheep Creek Range Analysis (2004), Musselshell Range Analysis (2002), Belt Creek Range Analysis (1998) and Castle Mountain Range Analysis (1997) improvements and grazing system changes are yet to be realized.

The direct and indirect effects to soils from roads and trails are expected to continue. The soils under established roads and trails will remain removed from the productive soils base. Erosion of the travel ways of roads and trails will continue, especially at the current level of maintenance. This level of maintenance is not expected to change (Gavrisheff 2006) except to possibly decrease. Soil compaction, cutbank sloughing, areas of mass movement, hillside slumping, flooding of roads and trails and rutting and breaking down of soil structure in soils with shallow water tables will continue.

b. Action Alternatives 2-5

The detrimental soil impacts from construction and use of roads and trails by different means of travel tend to be greater on sensitive soils. Detrimental impacts to soils tend to increase with greater levels of use and with kinds of use that exceed the physical capabilities of soils. Regular maintenance of roads and trails can help minimize soil impacts, especially erosion. Roads and trails with engineering designs and regular maintenance are generally more stable.

1. Direct and Indirect Effects

Budgets for road and trail maintenance are not expected to increase but hold at current levels or decrease in the future (Gavrisheff 2006). Table III-64 below is a simplification of Tables III-62 and III-63.

Table III-64.
Summary of Roads and Trails Crossing Land Types with Sensitive Soils and Segments of Roads and Trails with Grades Over 15% and Lengths Exceeding 1 Mile

Alternative	Total Miles of Roads and Trails Crossing Land Types with Sensitive Soils	Total Miles of Road and Trail Segments Steeper than 15% and Greater than 1 Mile in Length
1	839.9	1190
3	838.8	1183
4	674.1	1051
5	841.7	1175

Alternative 4 appears substantially different from the Existing Situation and other Action Alternatives. However, none of the totals in Table III-64 consider restoration of existing road and trail routes, system or undetermined. The specifics of decommissioning roads and trails (methods and timing) have not been developed for this project. Decommissioning measures could range from a gated closure to an effective restoration of soil and hydrologic functioning (relieving compaction, recontouring, draining, grading and seeding (Switalski et al. 2004). The rate of recovery of hydrologic and soil functioning would vary with the site. Recovery of hydrologic and soil functioning may be years away for some sites. Without restoration the Direct and Indirect impacts as described for the Existing Situation, Alternative 1 above, would continue.

2. Cumulative Effects

The Cumulative Effects for the Action Alternatives (Alternatives 2-5) are the same as for Alternative 1, the Existing situation.

c. Effects Common to All Alternatives

1. Direct and Indirect Effects

Natural disturbance events will continue to influence erosional and hydrologic processes within the watersheds of the analysis area. Given the current vegetative conditions, drought and associated fuel accumulations, there is potential for wildfires to occur that may be outside the range of conditions (intensity and duration) that have occurred over the last few hundred years. Depending on the intensity and area burned, accelerated soil erosion is possible, particularly where hydrophobic soils may be formed on moderately steep or steeper slopes of landforms that have had stream erosion as a primary process in their formation. Soil erosion could be expected, especially during years of average or higher precipitation/runoff conditions. Soils will stabilize as vegetative recovery progresses.

Road and trail systems have less of an impact to analysis area soils than natural disturbances such as wildfire. Construction and use of roads and trails are chronic sources of erosion and sediment to the analysis area watersheds.

Established road and trail surfaces are essentially removed from the productive soils base (Gucinski et al. 2001). Building and construction of roads and trails removes vegetative cover and changes the physical properties of bulk density, infiltration rates, water holding

capacities, nutrient concentrations and gas exchange rates. Roads and trails can intercept surface flows, concentrating runoff and directing flows and erosion toward streams (Wemple and Jones 2003). Roads and trails built across sensitive soils with a high risk of mass movement undermine upper slopes and increase the risk of soil movement and mass failure (Gucinski et al. 2001). Roads and trails built across shallow, weakly developed sensitive soils on steep slopes, especially at high elevations, are prone to erosion because these soils are difficult to stabilize. Segments of roads and trails may be jumbled and carried downslope if built on sensitive soils and landforms prone to slumping. Roads and trails built on floodplains may be severely eroded or removed during major flooding events. Roads and trails built on soil with shallow water tables may severely rut and lose structure due to low bearing strength.

Soil impacts from roads and trails tend to be more severe at high elevations due to higher precipitation rates, an extended period of snowmelt resulting in muddy soils, more severe freeze/thaw cycles causing more loose soil and increased exposure to wind erosion (Leung and Marion 1996).

Road and trail impacts to soils continue once established since the soil comprising the travel way is subject to continuing erosional forces of rainfall, running water, wind, freeze/thaw cycles, gravity and traffic (Leung and Marion 1996; Switalski et al. 2004; Summer 1986). Soil impacts are lessened or removed with restoration of roads and trails and establishment of effective vegetation.

Soil impacts from roads and trails tend to increase with increased use, with some means of travel and on steeper slopes. Studies in southwest Montana and northwest Wyoming (Dale and Weaver 1974; Weaver and Dale 1978; Wilson and Seeney 1994) have shown that on gentle slopes people and horse trails tend to be wider in meadows than in forests. Trail widths of horse trails in meadows were between 40 and 80 inches wide with 3000 or more uses per year. Horse trails on gentle slopes were nearly twice as deep as hiker trails in forested sites and 50 percent deeper in meadows. On sloping sites trail widths and depths increase over gentler slopes. Researchers found on meadow trails that motorcycle damage was greatest when traffic was upslope while horse and foot traffic was most damaging when the traffic was downhill. Weaver and Dale (1978) concluded: “Damage generally increased from hiker to motorcycle to horse in our study; of ridden at less conservative speeds, i.e. greater than 20 km/h, motorcycles might be more damaging than horses.” Findings in the three state Off-Highway Vehicle EIS (USDA and USDI 2001) that included Montana: “The degree of disturbance and compaction varies by site and would correspond to the type of driver, vehicle, tire tread, tire width, weight, angle of force to the soil and vegetative cover. Usually, compaction increases as tire size decreases, or vehicle weight increases and forces such as turning, accelerating or braking are added.”

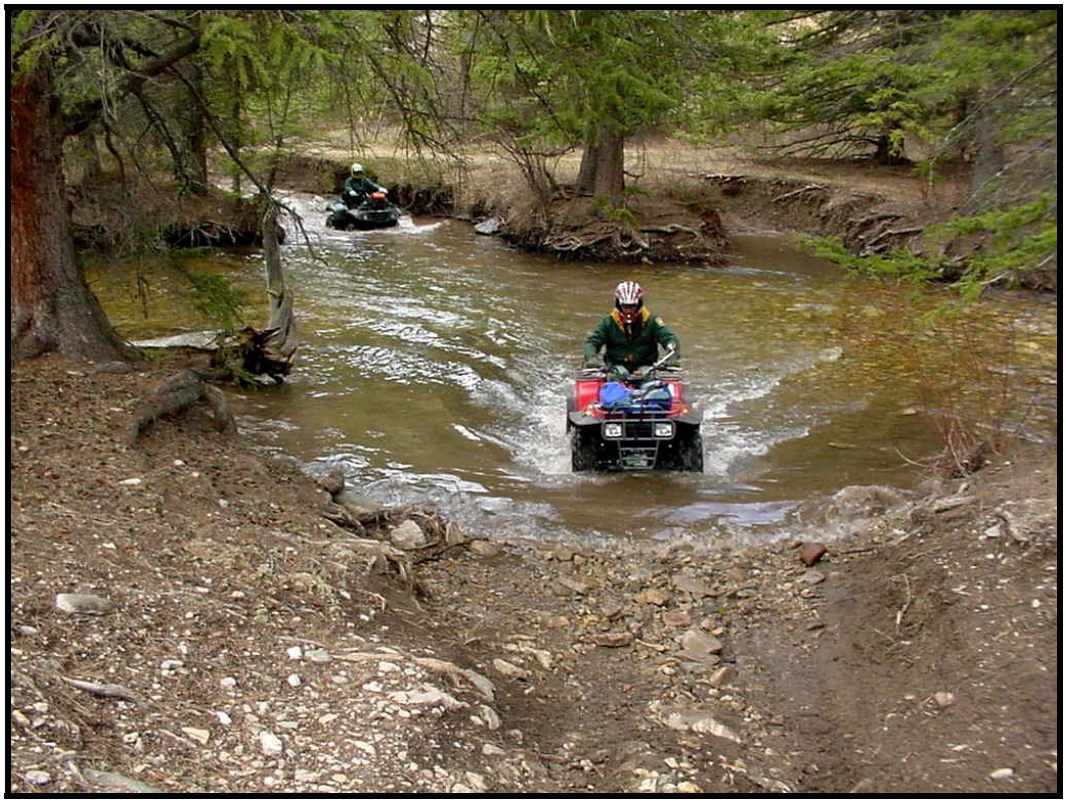
Most primary roads have been engineered and designed to limit erosion and sedimentation. Lack of maintenance leads to rutting and loss of surfacing, if present, and increased erosion and sedimentation (Seyedbagheri 1996; Swift 1984; Foltz and Burroughs 1990). Primitive two-track roads have little engineering and are prone to rutting and erosion if not maintained regularly. Trails have less impact but the travel way is usually bare and compacted with the risk of accelerated erosion and sedimentation.

The current level of road and trail maintenance is largely based on funding and Forest priority. Only 3-9 percent of the roads in the analysis area were maintained regularly between 2000 and 2005. The roads that have received maintenance are among the most improved and also thought to be most used roads in the analysis area. Only 4-12 percent of all trails receive some maintenance each year. The trail maintenance focuses on the most developed trails. From Table III-62, Miles of Roads and Trails Crossing Land Types with Sensitive Soils by Alternative and Travel Class, approximately 840 miles of land types with sensitive soils are crossed by roads and trails in the analysis area. The risk of soil impacts adjacent to roads and trails and the risk to water quality of perennial streams from roads and trails that are currently receiving little or no maintenance is moderate or greater. The current levels of road and trail maintenance will hold or decrease in the future (Gavrisheff 2006).

2. Cumulative Effects

Cumulative Effects described above for the No Action and Action Alternatives are very similar. Potential impacts from wildfire, prescribed fire, livestock grazing, timber harvest and existing roads and trails are described above under the No Action Alternative (2.a.2.).

d. Effects Common to All Action Alternatives

1. Direct, Indirect and Cumulative Effects

The direct, indirect and cumulative effects for Action Alternatives (Alternatives 2-5) are the same as for the effects common to All Alternatives above (2.c.).