appear to avoid natural or human-made openings and often actively hunt in them (Mech 1970, personal observations). Lynx can readily move across landscapes fragmented by commercial forestry (Ruggiero 2000), and Hornocker and Hash (1981) found that wolverines in Montana crossed large clear-cuts but did not appear to hunt in them. Timber harvests at the scale that are likely to occur on National Forest System land do not appear to be barriers to these species that are likely to make long distance movements.

Vegetation treatments on National Forest System lands become fairly insignificant in relation to long distance movements. In traveling over 150 miles (for example, the movement of wolf #9013 from Glacier National Park to Kelly Creek, Idaho), a 40-acre timber harvest unit is not a big deterrent for a wolf.

Determining a corridor or linkage is mostly guesswork, but barriers to wildlife movement are more apparent. When considering large-scale, long distance movements, one should look for large-scale, long-term barriers. Large highways are probably the most obvious barriers to wildlife movement. Just consider the number of bears, wolves, eagles and other wildlife that are killed on Montana highways. A map of Lynx and Carnivore Linkage Areas and Highway Crossings (Ruediger, pers. com.) shows most of I-90 as a potential barrier. Highway 12 just north of the project area is not likely a barrier in its current state. Highway 93 to the east of the project is becoming a significant barrier although work is being done to mitigate these impacts. Such highways are large permanent barriers that are probably only going to get worse as human populations increase. Railroads have a similar impact. Conversely, areas that have been subject to even intense timber harvests and fires do grow back into travel and hiding cover. Paved roads and subdivisions rarely return to wildlife habitat.

Direct, Indirect and Cumulative Effects

The two action alternatives propose altering the vegetation but those changes are consistent with the naturally fragmented habitat. These vegetation treatments are designed so the area will grow back to forest cover. None of the alternatives increase the open road density. Because none of the alternatives alter vegetation beyond patterns that occur naturally because of fire and other disturbance and open road density does not increase, these alternatives have **No Impact** on fragmentation, corridors or linkages.

Hydrology and Fisheries

Introduction

This report summarizes the characteristics, ongoing processes, and primary issues in the Butte Lookout Analysis Area (West Fork Butte Creek Watershed) for water and fisheries resources, in addition to the indirect, direct, and cumulative effects of the various alternatives. West Fork Butte is the largest and most downstream tributary to the South Fork of Lolo Creek.

This document provides landform, geology, and soil information most pertinent to hillslope hydrology, stream function, and aquatic habitat conditions. For a more detailed description and characterization of geology and soil related information, refer to the Butte Lookout Soils report.

Forest Plan Direction (and other direction if applicable)

Guidance and regulatory requirements affecting water and fisheries resources come from a number of Federal and State Acts and regulations. Refer to Appendix WF-1 for a comprehensive summary of regulatory, guidance, and coordination information.

Riparian Management Objectives

The Lolo NF has updated Inland Native Fish Strategy Riparian Management Objectives (INFISH RMOs) for the localized conditions on the Forest for all habitat variables except temperature. The refined RMOs include a larger suite of habitat variables than originally specified in INFISH (1995), and are more descriptive of relevant fisheries and aquatic habitat conditions on the Forest. The Lolo RMOs are described in the document "An Analysis of Fish Habitat and Population Conditions in Developed and Undeveloped Watersheds on the Lolo National Forest" (Riggers et al, 1998), which is available upon request. In general, the streams in the analysis area achieve RMOs, and the capability to maintain RMOs is high with proper management.

Desired Future Condition

In addition to providing goals, objectives, standards, and guidelines for managing water resources and fisheries (see Appendix WF-1), the Forest Plan identifies the following desired future conditions for these resources:

> In all streams, the desired condition is for instream sediment, woody debris, and riparian structure and function to be at conditions expected without human impacts with the acknowledgement that some variability on both sides of the mean is expected.
>
> Watersheds will be maintained in dynamic equilibrium that allows them to respond to climatic and tectonic events. They will absorb and release precipitation in a manner securing favorable water flows for stream channel maintenance, riparian function, and the protection of beneficial uses. Stream channels will exhibit the dimension, pattern and profile reflective of natural processes at work within their watersheds. They will achieve or retain their characteristics of: (1) accessing their floodplains; (2) maintaining local water tables; and (3) transporting and depositing natural sediment loads. Vegetative community types necessary for maintaining and supporting these functions will remain present. Inputs of water, sediment and large woody debris will be a function of natural processes.
>
> Fish habitat will be restored or maintained to provide physical, biological and chemical parameters typical of those found in naturally functioning watersheds. Habitat development and maintenance will be a function of natural processes and their natural range of variability within the watershed. Connectivity will be restored or maintained in all stream systems containing native fishes. Native fish populations will be restored or maintained as healthy and viable populations throughout their historic ranges. Stronghold populations capable of recolonization will be present across the landscape commensurate with a high probability of conserving genetic diversity. Desirable non-native fish populations will be managed to have no significant negative impacts on native populations.

Consequences of Not Reaching Desired Future Condition

If the desired future condition is not achieved, cumulative stresses on the aquatic environment will likely result in significant consequences to beneficial uses and aquatic organisms. For example, the probability of not meeting Water Quality Standards in the future will increase, the ability of stream systems to handle high flows without land loss will decrease, maintenance of structures on or near streams will increase, the ability of the forest to complete output-related projects will decrease, and the risk of extirpating local populations of Federally listed species will increase.

It is important to note that the desired future condition is not something that can be achieved immediately. Planned activities should be developed to move towards the desired future condition at a meaningful rate. In some areas, other issues such as land ownership patterns may limit our ability to achieve desired conditions, or the timeframe in which we can achieve them.

Analysis Area Boundary or Geographic Area

The Butte Lookout Analysis Area includes all of the West Fork Butte drainage area consisting of Marshall Creek and Cooper Creek as the primary tributaries. This is the analysis area for direct and indirect effects. Cumulative effects are considered for West Fork Butte and the South Fork of Lolo Creek. The majority of the watersheds in the assessment area are in National Forest System jurisdiction, with only four square miles in private holdings, which are located in the lower elevations of the drainage. The South Fork of Lolo Creek watershed drains an approximately 57 square mile area with 17 square miles, or 29 percent of the watershed, in the Selway-Bitterroot Wilderness. Most of the basin is located in Missoula County with the southern most reaches being located in Ravalli County.

Analysis Methods

The methods used to determine the existing condition and the effects of the alternatives are discussed in detail in Appendix WF-2. Briefly, the existing condition was established using the following: roads analysis, assessment indicators, and reference conditions. The effects of the activities proposed in the action alternatives were identified by evaluating the following: water quantity and yield; roads and road density; road encroachment on riparian zones; and sediment delivery.

Existing Conditions

Geographic Area and Climate

The Butte Lookout Analysis Area includes all of the West Fork Butte drainage area consisting of Marshall Creek and Cooper Creek as the primary tributaries. The elevation ranges from 3,500 feet at Lolo Creek to 8,900 feet at the headwaters of the South Fork, along the Idaho-Montana divide. Average annual precipitation is approximately 60 inches per year and varies from 100 inches along the divide to 30 inches per year in lower elevations. Rainfall, snow melt, and groundwater discharge are the primary components of flow in the area. Available snowmelt is the main source of rise and falls in the spring and summer hydrograph. During other times of the year, flows decrease substantially and generally are the result of released soil moistures and groundwater discharges. Summer thunderstorms are common and can cause streams to rise for short durations.

Geology, Landforms, and Soils

The South Fork of Lolo Creek begins on high elevation alpine ridges, glacial cirque headwalls and glacial cirque basins. These landforms have a high percentage of rock outcrops, avalanche chutes, and natural landslides because of the inherent potential weakness of the parent material. Sediment delivery for the entire area is efficient because of steep concave slopes and high drainage densities. Although parent materials vary from Precambrian belt rocks to schist, gneiss, and granite, the majority of these watersheds lie in erosive granitic or micaceous-schist landforms of the Idaho Batholith. When disturbed or left without vegetative cover, these landforms can be very erosive. They can also be subject to compaction because of moderate to very low bearing strengths.

The soil and substratum are relatively deep and have a good capacity for water storage. High amounts of ground water move through the soil mantle in these landforms, and springs are common because water tables are often at or near the surface. Relatively steep slopes, high water table, high drainage density, and higher annual precipitation all magnify erosion potential, if soil mantle disturbance should occur. Erosion and sediment transport is typically in the form of surface erosion and minor slumping rather than mass failures.

Wetlands

Wetlands are “areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (U.S. Army Corps of Engineers, 1987). Wetlands are delineated based on hydrology, soils, and vegetation characteristics. Swamps, bogs, marshes, and wet meadows are examples of wetlands.

Because the landscape of the project area is mainly defined by stream channel incision, most of the wetlands are directly associated with streams, although some areas are associated with road-side ditches. Consequently, wetlands are generally disseminated throughout the area and require a field review for identification and delineation prior to project level work. The most noted wetland in the project area is called Mary’s Frog Pond which is located across Marshall Creek from proposed unit 35 in the southern part of the analysis area.

Stream Channels

Historic (pre-development) large-scale natural events such as fire, windthrow, and floods, occurred at infrequent intervals and often do not affect every drainage simultaneously or at the same magnitude. As a result, landscape conditions were typically stable and similar throughout most of the watershed for the Holocene period (last 10,000 years to present). Considering the mechanics of streams (in a relatively stable landscape and geology) as they react to fire and floods, stream conditions have been in dynamic equilibrium, or relatively stable condition, for thousands of years (stable defined as the ability of the stream to transport the flow and sediment generated within the watershed while maintaining a relatively constant dimension, pattern, and gradient, without aggrading or down-cutting (Rosgen, 1996)).

Although the streams in the analysis area are relatively stable, they are sensitive to disturbance and lower gradient reaches are very subject to bank erosion. Bank

vegetation and natural levels of instream woody material are important for the majority of stream types. Sediment supply varies, but in general the system has a high natural sediment supply because of the granitic geology. Recovery potential depends on the stream type and has a wide range of responses, but overall the recovery potential is "good" to "excellent" (Rosgen, 1996).

Bulltrout Baseline Analysis

Based upon the document "A Framework to Assist in Making *Endangered Species Act* Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale" (Fish Wildlife Service 1998), individual or grouped activities will have a determination of effects and baseline conditions conducted at the 5th or 6th field HUC scale.

At each 6th code HUC the environmental baseline condition was assessed using the "Matrix of Diagnostics/Pathways and Indicators" and the "Checklist for Documenting Environmental Baseline and Effects of Proposed Action(s) on Relevant Indicators" (Fish Wildlife Service 1998). To aid in developing these baseline conditions GIS analysis of the Forest's watersheds was conducted. This analysis involved the use of many different GIS layers which included road, stream, harvest, mining, landownership layers, and satellite imagery (for streamside canopy cover). Using these different layers allowed the calculation of the number of stream crossings, Land System Inventories, INFISH Buffers, road densities, percent of streams with roads within a 300 foot buffer, percent of stream without shade, percent of Forest Service land in a vegetative regenerated state, percent of private land within the drainage area, etc. The generation of this data along with the use of a modified-Matrix (Riggers et al 1998) allowed Forest personnel to make consistent baseline calls for each 6th code across the Forest. Tables 39 and 40 provide a list of those sub-watersheds and a summary of some of their physical characteristics.

Table 39 Summary of 1998 Bull Trout Baseline GIS Data for the Lolo Watershed by 6th Field HUC.

6th Code Name	HUC Area (Mi^2)	% FS Ownership	% of HUC in Regen. Harvest	Grazing Allot. Status	Range Allot. Acres	Road Density (Mi/Mi^2)	% Stream with Road w/in 300'	% Stream with Road w/in 125'
Cloudburst_Lolo	22	63	2.7	Inactive	132	4.36	41.79	21.78
E Fk Lolo Cr	32	62	4.7	Active	20418	4.36	54.48	23.4
Granite Cr	20	71	4.1	Inactive		4.12	50.53	25.87
Graves_Woodman	19	57	5.3	Active	5342	6.18	60.43	35.73
Howard Cr	56	52	3.7	Inactive	12141	4.65	49.69	27.27
S Fk Lolo Cr	39	92	3.6	Active	6277	1.24	14.44	5.98
Sleeman_Mormon	51	40	1.3	Active	1104	4.54	45.85	23.39
W Fk Butte Cr	18	90	14	Active	10439	4.25	38.92	19.21
W Fk Lolo Cr	17	52	6.4			4.8	63.31	23.51

FA= Functioning Acceptably FAR=Functioning at Risk FAUR=Functioning at Unacceptable Risk

Table 40 Summary of the 1998 Bull Trout Baseline Species and Habitat Parameters for West Fork Butte and South Fork Lolo Creeks.

Diagnostic/Pathways: Indicators	West Fork Butte 6th Field HUC	South Fork Lolo 6th Field HUC
	FA/FAR/FAUR	FA/FAR/FAUR
Characteristics Subpopulation:		
Subpopulation Size	FUR	FUR
Growth & Survival	FUR	FUR
Life History Diversity & Isolation	FUR	FUR
Persistence and Genetic Integrity	FUR	FUR
Water Quality:		
Temperature	FA	FAR
Sediment	FUR	FAR
Chemical Contam. / Nutrients	FA	FAR
Habitat Access:		
Physical Barriers	FAR	FA
Habitat Elements:		
Substrate Embeddedness	FUR	FAR
Large Woody Debris	FAR	FAR
Pool Frequency & Quality	FUR	FAR
Large Pools	FUR	FAR
Off-Channel Habitat	FUR	FAR
Refugia	FAR	FAR
Channel Condition & Dynamics:		
Wetted Width/Max Depth Ratio	FAR	FAR
Streambank Condition	FAR	FAR
Floodplain Connectivity	FAR	FAR
Flow & Hydrology:		
Change in Peak/Base Flows	FUR	FAR
Drainage network Increase	FAR	FA
Watershed Conditions:		
Road Density & Location	FUR	FAR
Disturbance History	FUR	FAR
Riparian Conservation Area	FAR	FAR
Disturbance Regime	FAR	FAR
Integration of Species & Habitat Condition	FUR	FAR

FA= Functioning Acceptably FAR=Functioning at Risk FAUR=Functioning at Unacceptable Risk
The bull trout baseline analysis is a good measure at the 6th field HUC scale (ie. mid-scale) and does not take the place of stream reach specific data.

Inland West Watershed Reconnaissance

An overview of current stream conditions is provided by protocols associated with a previous assessment termed the “Integrated Stream Condition” (USDA, 1998). Table 41 below displays information from the South Fork Lolo Creek Watershed Assessment (1997), combined with recent interpretation for each 6th Field HUC (watershed of generally 10,000-40,000 acres).

Table 41 1998 and Updated 2007 Integrated Stream Condition

Inland West Watershed Reconnaissance Assessment	W. Fk. Butte	S. Fk. Lolo
Watershed Vulnerability	FAR/FAR	FAR/FAR
Geomorphic Integrity	FAUR/FA	FAUR/FA
Water Quality Integrity	FAUR/FAR	FAUR/FAR

FA= Functioning Acceptably FAR=Functioning at Risk FAUR=Functioning at Unacceptable Risk

According to assessment protocols (USDA, 1998), "Watershed Vulnerability" reflects inherent risks of conditions becoming degraded if certain sensitive lands in the watershed are disturbed." This parameter was termed "high" because of the erosivity of granitics - integrated with the amount of road development, road-stream crossing density, and road position relative to streams. At this time, the drainages are still considered Functioning At Risk for the same reasons; however, there are changes to the interpretations based upon advancements in stream data assessment, management changes, continued monitoring, and recent field reviews.

"Geomorphic Integrity" primarily reflects physical soil-stream resilience, which based upon previous analysis, was rated low because of the number of roads on the landscape. However, these streams have been monitored several times by field crews and specialists since the mid-1990s and stream recovery has been substantial. Stream conditions have improved more and sooner than originally expected, mostly contributed to a substantial change in grazing allotment management (see grazing section below).

"Water Quality Integrity" reflects overall water quality in a subwatershed, and although stream condition has markedly improved (changes have been made in the interpretations), most interpretations remain Functioning At Risk because of existing road related effects (i.e. primarily tied to sediment deliveries associated with road surface runoff and undersized culverts – see subsequent sections).

Stream Morphology and Aquatic Habitat Parameters and Condition

Stream channels are broken into types A through E based on characteristics such as gradient, entrenchment, dimension, and sinuosity. Channel Types B and C are used to characterize stream conditions so that relatively consistent comparisons of stream structure and function can be made to reference conditions. Only these "response" stream types are used for monitoring because they are lower gradient and are more sensitive to change or alteration; and therefore, are better indicators of condition than other stream types. Specific indicators and data are described below.

Pool Area, Volume, and Frequency – Pool metrics refer to quality and abundance of pools occurring in a given length of stream. Pools are perhaps the most important physical aquatic habitat component for fisheries assessment. Generally, the larger, deeper, and more complex pool habitat is, the greater its value in terms of fish utilization. Frequent pools are also an attribute to stream function as the majority of current velocities are dissipated in pools, thereby keeping erosive forces in check and bank erosion reduced.

Large Woody Debris - Large woody debris (LWD) is extremely important in developing complex habitat and pools in stream systems. It consists of primarily larger diameter

trees which enter the stream and affect stream hydraulics. LWD is often the main feature responsible for creating and maintaining pool habitat.

Width/Depth Ratio - Width/depth ratio is the relationship of a stream's mean width to mean depth. When streams are impacted by excessive erosive energies or bank alteration, they generally respond by becoming wider and shallower. Narrower, deep channels are generally better in terms of providing high quality fish habitat for native populations.

Percent Surface Fines - Percent surface fines (PSF) is a measure of the amount of fine material (less than 0.25 inches) covering the stream bed. PSF is a good indicator of the relative amount of erosion occurring in a watershed, and has been shown to be generally higher and more variable in roaded vs. unroaded watersheds on the Lolo National Forest (Riggers 1998). Geology also plays a substantial role in stream substrate distributions, and streams of granitic origin have higher natural levels of percent surface fines than other geologies, such as the Belt Supergroup. High levels of surface fines can negatively impact spawning success and can reduce the quality and quantity of juvenile rearing habitat available. High PSF can also negatively impact aquatic macroinvertebrate production, resulting in a decreased food base for native salmonids.

Relative abundance of both fine and larger stream substrates is an important consideration. Streams showing above natural levels of depositional sediment and bar developments of excessive bedload, may indicate an overload of sediment to the stream system, and therefore affecting the streams ability to transport sediment, as well as a variety of other effects, including additional bank stress and habitat alterations. Streams naturally have a base level of sediment that each year is flushed and replaced by new material, but when sediment supply is too great, stream capacity can be insufficient of flushing excess sediment. Sediment accumulations can begin to alter substrate composition by filling voids in interstitial spaces between larger particles. This process negatively impacts natural deposition and scouring processes, reduces habitat for invertebrates, and diminishes or precludes fish egg production. It also causes increased turbidity levels, which often results in degraded conditions downstream.

A previous landscape scale assessment, the South Fork Lolo Creek Watershed Assessment (1997), incorporated all available information at the time. This assessment displayed 1997 stream channel data; however, the information in this assessment no longer accurately describes conditions because of three issues: 1) stream conditions have improved since 1991; and 2) this Butte Lookout analysis is more comprehensive because a) channel conditions have changed, and b) project-level assessment provides more detailed evaluation of stream and reference conditions; and 3) the Butte Lookout analysis determined that stream condition is better derived from comparisons to granitic data references rather than belt derived references. The net result is that 1991 and 1995 parameters that were displayed as out of natural ranges actually fall within natural ranges. Table 42 below provides data from 1991, 1995 and 2006 surveys.

Table 42 General Stream Conditions As Indicated by Response Stream Reaches

Habitat Parameter	Representative Response Reach Condition							
	Rosgen C3 Channel Type				Rosgen B Channel Type			
	Granitic Reference Data (Riggers et al 1998)	1991 Data	2006 Survey /Recon	General Condition	Granitic Reference Data (Riggers et al 1998)	1995 Data	2006 Survey/ Recon	General Condition
Pool Area %	23(9-37)	15	Typical/ Good	Typical of Reference	24(4-44)	3.6	Typical/ Good	Typical of Reference
Pool Vol.	11.9 (2.6-21.3)	10.5	Typical/ Good	Typical of Reference	4.2(2-11.5)	4.4	Typical/ Good	Typical of Reference
Active LWD Pieces /Km	6-261	330	183	Typical of Reference	97(6-261)	345	166	Typical of Reference
Wetted Width/Depth Ratio	24(14-34)	23	Typical Bankfull Width	Typical of Reference	26(16-39)	16	Typical Bankfull Width	Typical of Reference
Percent Surface Fines %	8 (0-16.5)	12.4	2.8 (0.68-9.5)	Typical of Reference	7.6(0-20.9)	52	4.3 (2.0-8.1)	Typical of Reference
Percent Bank Erosion %	0.36(0-2.25)	6.4	Typical/ Good	Typical of Reference	0.36(0-2.25)	0	Typical/ Good	Typical of Reference
Percent Undercut Bank%	6(0-21)	8.9	Typical/ Good	Typical of Reference	6(0-36)	62	Typical/ Good	Typical of Reference

Although direct comparisons between surveyed values between years should not be made (i.e. surveys may not have been collected in the exact reach and were taken by different personnel with perhaps different survey methodology), every assessment parameter is within natural ranges as compared to reference condition data and typical stream values of C and B stream types, as observed during the 2006 field season. This data, and updated reconnaissance, reinforce what is noted in Table 41 above. That is, streams are functioning within natural ranges of morphology and habitat parameters, with no noted impairments. The channel stability rating (Pfanchuch, 1978) ranges from “good” to “excellent” depending on the reach surveyed.

However, road and crossing surveys, reinforced by modeling efforts, indicate that fine sediment deliveries (all associated with road and ditch surface erosion rather than no mass wasting) are of high concern, and will be discussed in subsequent sections. In addition, although LWD values indicate existing conditions are within natural ranges, and pool habitat appears adequate, conditions are not optimal in areas where the road is within 125 feet of the stream (which is generally one tree length on these sites). In other words, the road travelway and clearing limits eliminate existing and potential trees from shading and falling into the stream, and although firewood cutting is not allowed within 150 feet of the stream, trees are often removed that would otherwise contribute to habitat, shade, energy dissipation, or other stream, floodplain, and riparian functions.

In addition, past surveys have noted elevated amounts of bedload with noted bank erosion caused by dispersed camp site impacts, grazing, and riparian harvesting conducted by Plum Creek. However, recent surveys did not indicate these impacts or source, which could be attributed to the improving stream condition associated with the change in grazing management and/or lower stream discharges associated with drought

conditions. Because stream banks appear stable and vegetated, the bedload trend towards improved stream stability and less downstream contributions is most likely contributed to less bank collapse and erosion from cattle not being in the area for many years. Also, at least one of the known dispersed campsite areas has been remedied through road decommissioning, and there are no known cumulative harvesting impacts from other landowners at this time.

Stream Temperature

Stream temperatures on the Lolo National Forest have generally not been significantly different from reference conditions (Chatel 1993), which appears true for streams in this assessment area as well. Temperature data for the South Fork Lolo Creek watershed is based on July and September spot measurements at the time of the stream surveys, which indicated that summer temperatures are well below maximums outlined in INFISH. Aerial photo reviews reinforce this information, as they clearly show riparian vegetation conditions that are likely sufficient to maintain stable, natural ranges of summer and winter temperatures. Stream temperatures are therefore not assumed to be a problem.

Water Yield

Climate Sources and Trends

Snow accumulation and melt phenomenon sustain yearlong streamflow in perennial streams in the analysis area. The average annual runoff from the analysis area is approximately 20 inches (slightly more than the 18 inches considered to be the Lolo NF's average annual water yield). Similar to world-wide and local climate phenomenon, this area is experiencing climate conditions that are outside of normal conditions. Most pertinent to these watersheds, the area is experiencing less than normal runoff conditions for several years, which directly corresponds with less than average snow and rain amounts.

The most direct consequences of less precipitation relative to stream condition and aquatic habitat is that the streams have experienced less scouring forces associated with spring runoff as well as lower base flow conditions. Regarding channel morphology, pools and overall substrate interstices are likely to have increased quantities of smaller-sized sediments as compared to climatic normal conditions, and pools are likely not as deep because of the lack of substantial scouring forces. In addition, stream banks have not experienced high stress conditions, and therefore, bank erosion and undercut banks may be somewhat less than average conditions. Regarding base flow conditions and morphology, some types of vegetation are more likely to grow down into the active channel creating a lower capacity channel than normal, but impacts are most likely not measurable at this time. The most substantive impacts from lower base flows are in effects to aquatic life, which will be discussed in subsequent sections.

Current Timber Harvest and Water Yield Condition

Timber harvest and vegetation loss from other events such as wildfire, under certain circumstances change snowmelt and stream runoff timing and magnitude. Each stream has a tolerance for the amount of flow conditions outside of normal conditions. When outside of normal ranges for long durations, stream morphology is likely to change. For example, if flows are higher than conditions in which the stream has evolved, bank erosion, scour, and/or increased bedload movement are likely to occur, and as a result,

stream channel characteristics such as pool frequency, bank angles, bank stability, width/depth ratios can be changed with associated increases in sediment deliveries.

From the early 1900s to the 40s and 50s, the project area received moderate timber harvest. In the late 50s through the 80s, much of the project area was heavily harvested. Past watershed assessments have noted water yield concerns both from modeling and reconnaissance efforts. Since the 1980s timber harvest has slowed markedly.

Equivalent Clear-cut Area (ECA) provides an indicator of the extent to which watersheds (especially the vegetative component) have been altered by past and foreseeable future activities. In general, watersheds having more than approximately 30 percent of their area in an “equivalent clear-cut” condition are considered to have a high potential for changes in runoff quantities and timing (Bethlamy 1975, Cheng 1989, Burton 1997). Although to be most accurate ECA data is evaluated in context of natural stand conditions and confirmed with actual channel response data. From a water yield perspective, 17% of tree crowns in a timber stand must be removed before changes in available soil moisture become measurable (Pfankuch, 1973).

In addition, and for improved accuracy purposes, the historic range of variability (HRV) is used to characterize the landscape vegetative structures in a historical context for water yield effects assessment. Within this range of conditions, the characterized average of these drainages, at any point in time, is approximately 14% non-stocked from recent wildfire disturbance and approximately 25% seedling and sapling structures (Dupuis 1998, Loskensky 1991 and 1993, PNW-GTR-405, PNW-GTR-385, PNW-GTR-382, Fischer and Bradley 1987, Arno 1980, Arno et al 1985, Habeck and Mutch 1973, Quigley and Cole 1997). These estimates are considered the best available science for analysis of the ECA. Refer to the Project File (Item WF-7) for a complete discussion of ECA.

Analysis done in 1997 using a computer model called WATSED predicted that the water yields in West Fork of Butte watershed was about 5% above natural conditions. While concerns were noted, the values were not placed in context with natural vegetation conditions and channel conditions. As discussed in the Lolo NF Plan, when a stream has a “Good” Channel Stability Rating, typically, a 10 percent water yield increase should not cause resource damage. The Plan also says when a stream has a “Fair” Channel Stability Rating, typically, an 8 percent water yield increase should not cause resource damage. At present, the Forest is working within these standards on most project activities. It is recommended that management activities maintain water yields (runoff) less than 8-10 percent increase above natural conditions depending on stream sensitivity and erosion potential.

Considering that channel stability is currently “good” to “excellent” and the historic ECA typically averaged 14-39% (as interpreted from average historic stand ages of 14% non-stocked and 25% seedling/sapling), the concern relative to the 5% value is reduced substantially. In addition, the water yield recovery rate of water yield is 60% when stands reach 20 years in age (Pfankuch, 1973). Taking natural stand conditions and recovery time into account, coupled with channel data, leads to a determination that currently stand conditions are not creating any water yield concerns. ECA conditions relative to the project are discussed in the Environmental Consequences section and Project File, Item WF-7.

Interpretation of water yield effects from roads are also addressed (Environmental Consequences), because roads can markedly affect water yield. They often react similarly to first-order streams by collecting water and routing them efficiently to lower elevations. In other words, water that normally would infiltrate the ground is captured on road surfaces and transported down ditches, which quite often deliver water directly to stream channels or near stream channel areas. Thus, high road densities can expand the network of stream channels and the areas contributing to runoff-producing events. If densities are great enough, the result is an increase in the rate of stream flow response and quantity.

Water Quality

The U.S. Environmental Protection Agency is charged with protecting water quality and setting minimum water quality standards in the United States. In most states, authority has been delegated to State agencies to enforce regulations and to refine water quality standards, setting more stringent standards where necessary. The Forest Service must meet State water quality standards when conducting management activities, and monitor its activities to verify compliance. Pertinent State water quality standards are noted in Appendix WF-1, although implementation and evaluation of BMPs are the primary means of ensuring that State water quality standards are met.

All water-bodies in the analysis area are classified as B-1 waters by the State of Montana, which are suitable for “drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply” (ARM 17.30.623).

The South Fork of Lolo Creek is listed by the Montana Department of Environmental Quality (DEQ) as being “Water Quality Limited” in a list known as the “303(d) List”. Although the State by court order must develop total daily maximum loads (TMDLs) for all streams listed on the 1996 list, sufficient credible data has determined that the South Fork of Lolo Creek “has no pollutant-related use impairment”, which means that TMDL development is not necessary, but the stream will need to be incorporated into a watershed restoration plan to address the noted impairments. Table 43 summarizes the use impairments for the South Fork of Lolo Creek. Probable causes of impairments are noted as flow and habitat related alterations from flow modifications, silvicultural practices, and forest road influences.

Table 43 State 303(d) Listed Water Body and Stream Description (1996)

Water body & Stream Description	Use Class	Aquatic Life	Coldwater Fishery	Drinking Water	Swimmable (Recreation)	Agriculture	Industry
South Fork of Lolo Creek	B-1	P	P	F	P	F	F

Legend: F= Full Support; P= Partial Support; N= Not Supported; T= Threatened; X= Not Assessed (Insufficient Credible Data).

Roads

Road densities in the project area are considered “high to excessively high” based on analyses conducted during development of the Interior Columbia River Basin Ecosystem Management Plan (ICBEMP). The Plan identifies densities between 1.7 and 4.7 miles per square mile as high; and densities greater than 4.7 miles per square mile are defined as excessive (Quigley et al., 1996). Where there is a combination of high road densities, sensitive soils, and close proximity of roads to streams, the potential for adverse impacts

to water resources greatly increases. Estimates for sediment deliveries from existing road conditions will be shown in Environmental Consequences section, along with the conditions that would result from proposed treatments under the various alternatives.

Photo 1 Road Intercepting Water, FS Rd 2175

The Lolo Forest Plan, Management Area 16, Standard 15 states, "Roads will be constructed and managed in a manner to keep sedimentation hazard "Low". Lolo NF data shows that when roading in a drainage approaches levels of 2 miles per square mile or more, sediment delivery levels began to be problematic and could be observed and measured in the stream (Riggers, 1998). ICBEMP presents similar results showing high and extremely high categories of road densities were creating measurable sedimentation (USDA, 1996). The findings showed that road densities of 1.7 miles per square mile (assuming the roads meet BMP standards) were considered to deliver "Low" levels of sediment. This was considered in ICBEMP to be within proper limits and could be interpreted, or considered when guiding road density management decisions, to correspond with the Lolo Forest Plan guidance for managing sedimentation hazards at "Low" levels.

In a 1981 report, Cederholm et al. determined that road density and hill-slope position can be major factors in the level of fine sediment within streams. It was found that when roads exceeded 2.5% of the drainage area that sedimentation of streams was at its greatest. It was also found that sediment production increased four times over natural rates when road density exceed 2.5 kilometer of road per square kilometer of area. Although road densities in general are high in the assessment area, there is a difference in the effects that a road can cause based upon hill-slope position, road age, soil saturation, geologic substrate, vegetation, and climate. Generally road segments with surfaces and culverts that drain directly to streams and those that cross

Photo 2. Ruts in Graveled Road, FS Rd 2175

the down-slope side of clear-cut areas are most likely to contribute significantly to runoff and sediment delivery (Wemple, 1994).

In the assessment area, the location of certain road sections (primarily NFSR 451), combined with the overall high densities and need for road improvements, in various forms, is producing negative impacts to stream function, aquatic habitat, and fisheries conditions. Impacts are mostly associated with fine sediment deliveries, large wood preclusion, and fish movement barriers at road-stream crossings. Reference the Environmental Consequences and the Transportation report for specific densities and identification of problematic road segments and road-stream crossings.

Roads constructed prior to the 1980s rarely were surfaced and did not have rolling grades or other treatments to control surface drainage. In the middle 80s, a sizeable portion of the West Fork of Butte Creek was roaded under the Cooper Creek Timber Sale, which graveled and improved drainage on almost 18 miles of system road. Of an estimated total of 63 miles, 59 percent of the road system (37 miles) is surfaced, 75 percent (47 miles) is closed to access year round, and 27 percent (17 miles) are constructed on soils considered very stable and low in erosion potential. Approximately 1.4 miles of existing road has been previously decommissioned (refer to the Transportation Report for additional detail). The decommissioned roads have been cross-drained, vegetated, and access to them eliminated by obliteration of the entrance(s). Road reconnaissance by the fisheries biologist in 2006 and 2007 found road segments where the gravel appears to weathering or was initially poor quality, resulting in rut develop of the road surface (see photos 1 & 2). These road segments are below current BMP standards, and ruts carry water down the surface of the road for several hundred feet, subsequently saturating the road surface and making it more prone to further rutting.

Photo 3. Ditch Drainage and Fillslope Erosion, FS Road 451

Within the cumulative effects area for the water and fisheries resources, road densities are approximately 2.2 miles/square mile (within the South Fork Lolo watershed, which includes West Fork Butte). However, approximately 10 square miles of lands suitable for development have not been developed (lower South Fork of Lolo Creek (east of the creek), Lantern, and Johnny Creek areas), and if these areas are removed from the calculation the road density increases to 3.3 miles/square mile. This value remains within Forest Plan standards, but is greater than recommended by the ICBEMP and Lolo NF studies for managing sediment deliveries in a “Low” status. Looking just

within the West Fork Butte 6th field HUC the road density is approximately 4.2 mi/square mile. These road density numbers do not include jammer roads, neither are they considered in the road densities discussed previously.

Jammer roads are also considered in road management decisions. These roads are not designed prior to constructing and are non-system roads that were used to access timber on steep slopes before the use of modern machinery. Jammer logging relied on constructing many narrow horizontal roads on steep slopes, resulting in a “terraced” landscape, with roads spaced as closely as 50 feet apart. While not considered in road density calculations, they are still features on the landscape that, depending on densities, location, and condition of stream crossings, may affect local hydrology and pose sediment delivery threats if rain or high runoff events occur after wildfire.

The lowest reaches of the South Fork of Lolo, and upper West Fork of Butte, and Marshall Creeks were harvested with high density jammer road systems in the 1950s through 60s. Surveys indicate riparian harvest from old skid road traces adjacent to streams and some evidence of skidding down stream bottoms. Most jammer roads appear to be well-vegetated but the presence and condition of culverts on these roads is not known.

Sediment Delivery

Roads can largely influence sediment yields. Because their surfaces are compacted, infiltration is limited which potentially speeds runoff and sediment to the stream network. These compacted surfaces and road prisms intercept relatively slow subsurface flow by capturing it from cutbanks and ditches and routing it down the road. Determining sediment delivery effects is complicated by a variety of road and road-stream crossing designs and maintenance conditions. However, in general, as more drainage ways are crossed, probabilities for direct sediment introduction increase substantially (Rosgen, 1991). In addition, the lower a road is on the hillslope, the more likely it will direct sediment to the stream because of proximity to the stream and a greater accumulation of upslope runoff (Sidle, 1980). Generally as road density increases, sediment delivery increases. Photo 3. illustrates rut development through the forest floor, below the outlet of a ditch relief culvert on NFSR 451. This type of rut development is a result of inadequate drainage and low bearing strength.

The South Fork Watershed Assessment estimated that the amount of fine sediment produced by roads in the West Fork of Butte Creek was more than twice what would occur naturally in Marshall, Cooper, and West Fork Butte Creek streams. This is primarily because the roads are located on more sensitive soils with much higher production rates than other nearby drainages. This current analysis concurs with the findings from the South Fork watershed assessment, although a different model was used (i.e. WEPP instead of WATSed).

The WEPP analysis (Elliot and Hall, 1997) of the contribution of roads to sediment outputs focuses on roads paralleling stream courses and road-stream crossings. These are the road segments that have the greatest potential to influence stream function and water quality. Jammer roads are also considered, but are generally well-vegetated and a minor potential sediment source. However, some jammer roads crossing drainages are a concern because drainage provisions are likely minimal to non-existent, with any possible older log-style culverts having most likely failed. The actual status of jammer

road-stream crossings is unknown and reconnaissance is necessary before the contract to decommission roads in the analysis area is completed.

Sediment delivery assessments and estimates are based on recent efforts of the Department of Environmental Quality (DEQ) in the St. Regis watershed for a Total Maximum Daily Load (TMDL) assessment. For this assessment, DEQ measured and recorded WEPP:Road parameters at approximately 20 sites on National Forest System roads, accounting for the same road sections and locations as those pertinent to the Butte Lookout assessment (i.e., generally road approach grades that chronically or episodically contribute sediment to the crossings - typically those segments that are within 300 feet). The DEQ assessment averaged mean annual sediment delivery contribution per crossing at 0.53 tons per year.

The DEQ determined value of 0.53 tons per year is used for this Butte Lookout assessment as well. All the road input parameters are identical between the two assessment areas, including road surface type. The only difference is the road gradients. The roads in the St. Regis assessment were steeper, thus making the use of 0.53 tons per year for the Butte Lookout assessment roads a conservative estimate of actual delivery. In other words, with high probability, average road surface erosion contribution at road-stream crossings in the Butte Lookout area is likely not higher than 0.53 tons annually.

In addition, this assessment also considers road segments within 300 feet of riparian areas in addition to the DEQ derived road-stream crossing assessment values. Therefore, the sediment delivery values from riparian road sections (Table 43) are added to the stream-road crossing values (Table 44) for a total sediment delivery for the watershed.

Table 44 Estimated Number of Stream Crossings with the Potential to Deliver Sediment and Associated Estimated Annual Sediment Delivery

Watershed	Estimated Number of Crossings	Existing Sediment Load[1]	Cubic yards/year (1.4 tons/cubic yard)
Face Drainages	22	11.7	16.3
Marshall Creek	23	12.2	17.1
Cooper Creek	11	5.8	8.2
West Fork Butte Creek	17	9.0	12.6
South Fork Lolo Creek	2	1.1	1.5
Totals	75	39.8	55.7

[1] Calculated by multiplying the # of crossings by 0.53 tons/year

Riparian Road Segments

Table 45 displays road segments within 300 feet of stream courses that are not accounted in the road-stream crossing assessment above in Table 44. Values were determined using silt loam soil texture of 50% rock content over 30 years of simulated climate data.

Table 45 Estimated Lengths of Riparian Road Segments and Potential Average Erosion and Sediment Delivery

NFSR	Grade	Avg. Width	Estimated Length w/in 300 feet of stream (miles)	Surface	Traffic	Ave. Distance to Stream (feet)	Ave. Buffer Slope	Erosion From Road Surface (tons/yr)	Sediment Delivery (tons/yr)[cubic yards/yr]
17123	2	14	0.5	grass	None	150	3	0.4	0.0 [0.0]
2136	6	14	0.25	native	low	200	10	2.6	0.6 [0.9]
2171	3	14	0.3	native	low	200	15	1.1	0.4 [0.6]
451	2	20	2.2	gravel	high	250	10	2.8	1.2 [1.7]
451	8	20	1.5	gravel	high	150	20	16.2	7.2 [10.1]
Total Sediment Delivery From Riparian Roads: 9.4 tons/year [13.2 cubic yards/year]									

Grazing

In the past grazing was closely scrutinized in the analysis area because it has impacted riparian zones and fish habitat by changing stream hydraulics, reducing bank stability and overhead cover/shade, increasing sediment, and reducing pool habitat quality. In the early and mid 1990s, assessments stated that these impacts were especially evident on private lands along Lolo Creek and the lower reaches of the South Fork, but also occur on National Forest System lands in the West Fork Butte Creek watershed. The lower reaches of streams are often the most productive areas, and impacts in these areas can have greater consequences than in other reaches. In the South Fork Lolo Creek watershed, the lower 1-2 miles in Section 31, which is private, is a critical spawning and rearing area, and has been historically impacted by grazing.

No grazing occurred in the undeveloped portion of the South Fork watershed. Grazing was permitted in the West Fork Butte Creek area on National Forest; however, the permit was terminated in 2008. As noted in the stream channel sections above, the streams have greatly improved from the cattle impacts.

Mining

In the 1960s, the Ward Lode groups of claims were developed. An open pit mine with associated spoil banks, a horizontal underground mine shaft, and numerous areas of surface exploration occurred in the Dick and the East Fork of Lolo Creek drainages. Most of the exploration occurred in highly erosive granitic soils. The effects of these mineral developments were producing excessive sedimentation impacts to Dick, Johnny, and the South Fork of Lolo Creeks.

In the early 1980s the Lolo NF began rehabilitation activities on the disturbed lands connected with this mine. These efforts focused on keeping sediment on site. During the summer of 1995, the slopes of the spoil bank were lessened and netting containing seed and mulch was installed to complete revegetation efforts on the site. Although portions of the area could benefit from additional revegetation, stabilization of the 9-acre site containing the open pit mine and spoil banks has been completed to a point where no off-site water quality impacts are resulting.

Fisheries

Historically, fish populations in the Lolo Creek drainage were dominated by fluvial westslope cutthroat and bull trout, which migrated out of the Bitterroot and Clark Fork

Rivers to spawn in Lolo Creek. Resident forms of these two species occupied smaller tributaries and headwaters of larger streams in the drainage. Other species, such as mountain whitefish, suckers, northern pike minnow, sculpins and dace were also present, and were important components of the aquatic ecosystem. Lolo Creek was likely one of the most significant spawning and recruitment tributaries to the lower half of the Bitterroot River because of its relatively large size, location within the Bitterroot, and abundance of low gradient stream reaches (C channel types) which provide high quality spawning habitat. Within the Lolo Creek drainage, larger streams such as the South Fork, West Fork of Butte, East Fork, West Fork, Granite Creek, Howard, and Lee Creeks were the most significant spawning tributaries for fluvial cutthroat and bull trout. Snowshoe Falls, about half-way up the West Fork, is a barrier to upstream migration. However, westslope cutthroat were able to move above the falls at some time in the past, because there are currently resident populations above this water fall. The rest of the stream network was generally accessible to migratory fish.

Because the Lolo Creek watershed drains relatively unproductive granitic geologies, fish population densities were probably never as high as in similar streams flowing through metasedimentary geologies. However, the higher proportion of C and E channel types (which generally provide more complex habitat per unit area than B and A types) in the watershed, relative to other similar-sized streams, may have compensated for the low productivity of the soils. The current population status for bull char in the South Fork Lolo Creek aquatic ecosystem is present-depressed, while that for westslope cutthroat trout is present-strong (Kramer et al 1994). Population densities of resident westslope cutthroat are moderate throughout the system (2.3 -12.3 fish per 100 square meters). Both resident and fluvial bull char population densities are low and occur primarily in the main South Fork Lolo Creek (1.9 fish per 100 square meters). Historically, this species would have occupied much of the West Fork Butte Creek drainage.

Fish species currently inhabiting the South Fork Lolo Creek watershed include westslope cutthroat, rainbow and brown trout, bull and brook char, mountain whitefish, suckers, northern pike minnow, dace and sculpins. Historically, rainbow and brown trout and brook char were not present in the watershed. Past stocking and illegal introductions of these species in the Bitterroot River and Lolo Creek has resulted in significant populations in some streams. Runs of migrating rainbow and brown trout ascend the lower reaches of Lolo Creek in the spring and fall. Some of these fish migrate into the South Fork Lolo Creek and West Fork Butte Creek to spawn. The upper limit of migration for these species is approximately 2 miles upstream of the mouth in South Fork Lolo Creek and approximately 2.5 miles upstream of the mouth in West Fork Butte Creek. In the South Fork of Lolo Creek, populations of native bull char and westslope cutthroat trout still exist in moderate densities. These populations are absolutely critical to maintain given the significance of the South Fork watershed in the lower Bitterroot River aquatic ecosystem. Maintaining strong populations in the best possible habitats throughout the landscape and preserving metapopulation structure and function are the best hedges against extinction (Reiman et al 1993).

Increases in stream gradient and reduction in stream size generally restrict movement of rainbow and brown trout further into the headwaters of these streams. Brook char are present in moderately high densities in streams that have easy access (mainly in the West Fork Butte Creek and tributaries). This species inhabits even the headwater streams where rainbow and brown trout are not generally found. The presence of these

non-native populations poses two risks to native cutthroat trout and bull char: (1) rainbow x cutthroat hybridization and bull char x brook char hybridization may occur, resulting in an overall loss of genetic integrity to the native stocks, and (2) interspecific competition between native and non-native species could result in reduced growth and viability of native stocks.

In 1991 Forest Service surveys of West Fork Butte Creek using fish shocking found 2.3 – westslope cutthroat, 0.3 – rainbow, 5.7 – brook trout, 0.3 – brown trout per 100 square meters. This shocking unit was lower in the watershed near the NF boundary. Cooper Creek was snorkeled in 1991 and presence was established for westslope cutthroat, brook trout, and bull trout. Montana Fish, Wildlife, and Parks (MFWP) field crews shocked three sections of West Fork Butte Creek in 2003. They found the following: Section 2 (near NF boundary) contained westslope cutthroat trout, brook trout, and brown trout; Section 4 (middle reach) contained brook trout and cutthroat trout: and Section 8 (upper reach) contained brook trout and westslope cutthroat trout. Marshall and Cooper Creeks were also surveyed by MFWP during this same time. They found that Marshall Creek shocking segments only contained brook trout and Cooper Creek shocking segments only contained westslope cutthroat trout (MFWP, 2003).

These sampling efforts indicate that population densities of bull char in West Fork Butte Creek are significantly lower than reference populations. Electro-shocking in these streams found no bull char in the areas surveyed. It is possible that remnant populations still exist in these drainages, but densities are extremely low. In Dick and Johnny Creeks (tributaries to South Fork Lolo Creek), population densities were probably never very high due to the difficulty of accessing these streams and their small relative size. West Fork Butte Creek, however, probably supported strong populations of bull char historically. The decline is largely attributable to previously mentioned changes in habitat which have occurred over the last century.

Although population densities can reflect the overall health of the aquatic ecosystem to some degree, it is extremely important to realize that other factors outside of the assessment area, such as fishing pressure, non-native species, and downstream access also have significant impacts which can outweigh impacts directly related to physical aquatic habitat. From the above discussion, two major conclusions are evident:

- Overall aquatic habitat and native fish populations are generally below desirable levels in West Fork Butte Creek and Dick Creek (tributaries to South Fork Lolo Creek),
- The changes in aquatic habitat and fish populations in West Fork Butte Creek are largely attributable to long-term impacts of intensive management activities in these watersheds over the past century.

In addition, aquatic habitat and fish populations are substantially different in managed (West Fork Butte Creek, Dick Creek) vs. unmanaged (South Fork Lolo, Johnny Creek) drainages within the South Fork Lolo Creek watershed. Most of the changes that have occurred as a result of human activities in the West Fork Butte Creek and Dick Creek watersheds are due to low-level chronic impacts which have persisted for nearly a century. It is important to note that the impacts are not from only one source. A combination of these impacts is responsible for the current poor conditions.

Risk of Local Population Extinction

The Bitterroot Section 7 Bull Trout Watershed conducted a baseline assessment, pursuant to the listing of bull trout, which classifies bull trout in of this project as "functioning at unacceptable risk" for all habitat and population indicators for the West Fork Butte Creek 6th Field HUC (USDA Forest Service 2000). This status call is based on an analysis at the 6th code HUC scale using a habitat and population indicator framework developed by the US Fish and Wildlife Service (USFWS 1998). Cutthroat trout are classified as "functioning at risk" for "sub-population size" and "growth and survival" population indicators (USDA Forest Service 2000). They are listed as "functioning at unacceptable risk" for the population indicators of "life history and diversity" and "persistence and genetic diversity". This is in large part from the fragmented nature of fish populations in these areas at the mouths of these creeks, as well as from regional fragmentation of habitat and population due to Milltown Dam upstream and the Thompson Falls/Noxon/Cabinet Gorge dam complex downstream.

Using the methodology outlined by Rieman et.al., 1993, risks of extinctions for westslope cutthroat trout and bull trout were estimated at the regional level and local level. The regional level was considered as the entire Lolo Drainage. Here the risk of extinction for bull trout was rated as high and westslope cutthroat trout was rated as low. This is due to increased fish barriers, suppressed native fish populations, introduced fish species, increased fishing pressure, and degraded habitats (USDA Forest Service 2000).

The risk of local population extinction for westslope cutthroat trout in the main South Fork Lolo Creek is low. Habitat quality and complexity is high, and the population size/structure is sufficient to provide long-term viability. Individuals are not isolated from other populations. There is a concern of hybridization with rainbow trout in this stream. Past genetic samples of cutthroat populations in the lower reaches of this stream showed hybridization (Leary et al. 1991). However, as previously mentioned, the steeper gradient in the narrow canyon approximately 2 miles upstream of the mouth seems to have prevented significant upstream migration of rainbow above this point at the present time.

The risk of local population extinction for bull char in West Fork Butte Creek is high. This rating is due to deterministic risks associated with growth and survival. Overall habitat quality/complexity in this watershed has been degraded by human activity. Bull char populations have been affected to a larger degree than westslope cutthroat due to their stronger need for a migratory life history. These habitats will not recover to predisturbance conditions within two generations (5 to 10 years), and this has resulted in reduced fish survival and growth rates from those in undisturbed habitats.

These risks are analyzed with respect to three general mechanisms of extinction: Deterministic, Stochastic, and Genetic. Deterministic extinctions occur when there is a cumulative loss of critical components in a species environment (e.g., loss of pool habitat). Stochastic processes are those risks that are a result of chance events (e.g., forest fires, mud slides, etc.). The genetic extinction mechanism is the loss of genetic diversity within a population. Depending on the nature of individual effects the result is usually an increase in the risk of extinction. For example, a culvert that is a fish passage barrier can separate a population in half. In this case, the population above the culvert is isolated and has a higher risk of extinction based on the inability of recolonizing from below. In addition to being isolated the continuation of the deterministic effects continues to deplete the population unless stabilized. Any given individual effect has the

ability to become synergistic in relation to the three mechanisms identified above, therefore, increasing the overall risk of extinction.

Critical Life Stage Areas and Limiting Factors

Critical life stage areas are those stream reaches that provide an important habitat component critical to one or more discrete life stage of the fish species of concern. They may or may not be in habitat types that are generally lacking in the watershed. Critical life stage areas are often spawning and rearing sites, but may vary in different watersheds based on specific limiting factors within these watersheds.

An analysis of the factors limiting native fish populations in the South Fork Lolo Creek watershed is essential in determining what life stage areas are critical and where they are represented throughout the watershed. Refer to previous discussion and Table 42 on specific habitat parameters and current conditions.

In general, current assessments indicate that habitat is generally in good condition. Although there are naturally high sediment quantities, as well as fine sediment primarily generated from roads. Stream condition on National Forest System and private lands has markedly improved in response to resting the area from cattle grazing. Reinforcing the previous discussion on sediment deliveries and associated conditions, while it is difficult to determine precisely, past surveys have indicated aquatic habitat in West Fork Butte Creek is impacted by high sediment levels. However, updated surveys have revealed that much of the noted sediment is likely natural and attributable to the dominance of granitic geology and soils.

Culvert and Fish Barrier Status

Except for South Fork Lolo Creek, streams in the analysis area have some degree of fish habitat fragmentation from culverts at stream crossings or natural features such as cascades. Eight road-stream crossings inhibit fish passage and have inadequate capacity to accommodate 100-year flood (Q 100) event requirements. These culverts are listed in Table 46 below in order of their priority for replacement or removal. A probable replacement structure along with an estimate of stream miles currently impeded is also displayed (See Appendix B, document b-10 for crossing locations). All of these structures are located within the proposed haul route with the exception of two crossings; Culvert ID #906 and #879. All of these crossings are considered to be at least partial barriers or are considered to be upstream barriers for part of the year.

Table 46 Fish Bearing Culverts within the Project Area

Culvert ID No.	NFSR	Replace. Priority	Drainage	Existing Structure	Bank-full Width (b)	Potential Replacement Structure	Stream Miles Impeded	Replace /Removal Plan
971	451	1	West Fk. Butte Crk.	81" x 59" CMPA (a)	13.1 ft.	18' x 7'-8" x 78'L BA(c)	9.0	Replace w/ Alternatives 4 & 5
902	2175	2	Cooper Creek	46" x 36" CMPA	7.6 ft.	137" x 87" x 40'L CMPA	0.5	Replace as Funds Are Acquired
874	2175	2	Cooper Creek	46" x 36" CMPA	8.2 ft.	142" x 91" x 40'L CMPA	0.3	Replace as Funds Are Acquired
899	451	3	Marshall Creek	30" CMP	10.5 ft.	171" x 110" x 66'L CMPA	1.0	Replace as Funds Are Acquired
1468	451	3	Marshall Creek	42" x 29"CMPA	10.6 ft.	171"x110" x75'L CMPA	0.05	Replace As Funds are Acquired
880	2175	4	West Fk. Butte Crk. Tributary	36" CMP	4.0 ft.	73" x 55" x 54'L CMPA	0.25	Removal – Alternatives 4 & 5
906	2174	5	Cooper Creek Tributary	36" CMP	7.5 ft.	137" x 87" x 36'L CMPA	0.1	Remove as Funds Are Acquired
879	2171	6	West Fk. Butte Crk. Tributary	24" CMP	3.0 ft.	66" x 51" x 42'L CMPA	0.1	Replacement is not planned at this time
Total Miles Partially or Totally Impeded							11.3	

(a) CMPA - corrugated metal pipe arch.
(b) Width of stream surface at normal yearly high water level.
(c) Bottomless Arch – corrugated metal pipe in arch configuration that has no bottom portion but instead is attached to concrete footings on either side of the creek.

Table 47 NonFish Bearing Culvert Removals

Culvert ID No.	NFSR	Drainage	Existing Structure	Bank-full Width (b)	Potential Replacement Structure
C2	2175	Unnamed Trib. to W. Fk. Butte	18" cmp	~2.0	Removal – Alternatives 4 and 5
C1	16726	Unnamed Trib To W. Fk Butte	18" cmp	~2.0	Replacement
C3	17144	Unnamed Trib. to W. Fk. Butte	18" cmp	~1.0	2 Removals – Alternatives 4 and 5

Summary of Existing Condition

All of the watersheds within the analysis area have been influenced by human activities with varied impacts, although most of the South Fork of Lolo Creek has remained undeveloped except for the lower reach. Human-related influences on water resources include wildland fire suppression, timber harvesting, roads, and grazing, which in turn have impacted streams, riparian areas, fisheries, and aquatic organisms. Fisheries have been additionally impacted by influences outside of the assessment area. The following items summarize specific findings of this assessment. Incorporating these findings will

assist management decisions in protecting and/or improving conditions by eliminating or mitigating existing problems and applying proposed actions that maintain, restore, or improve as appropriate and to the extent possible.

- The South Fork of Lolo Creek is listed by the Montana Department of Environmental Quality (DEQ) as being "Water Quality Limited". Although the State by court order must develop total daily maximum loads (TMDLs) for all streams listed on the 1996 list, sufficient credible data has determined that the South Fork Lolo Creek "has no pollutant-related use impairment", which means that TMDL development is not necessary, but the stream will need to be incorporated into a watershed restoration plan to address the noted impairments. Relative to this assessment area, all actions need to lead to an improvement of noted impairments.
- Although parent materials vary from Precambrian belt rocks to schist, gneiss, and granite, the majority of these watersheds lie in erosive granitic or micaceous-schist landforms of the Idaho Batholith. When disturbed or left without vegetative cover, these landforms can be very erosive. They can be also subject to compaction because of moderate to very low bearing strengths.
- Stream condition indicators show marked improvements and Riparian Management Objectives are achieved, with noted exceptions below. Improvements are resultant of the following activities:
    - Substantive efforts were made to change grazing allotment management to avoid and rehabilitate impacted stream segments, resulting in the permittee voluntarily removing cattle from the area.
    - The Ward Lode Mine site was rehabilitated, removing all sediment deliveries to tributaries.
    - There has been no significant use of the roads with in the West Fork Butte Watershed in the past 20 years; only about 5 percent of NFSRs are open to all motorized access year long.
    - Although more road work is needed, road gravel surfacing and additional drainage provisions have reduced some sediment delivery problems.
- Parameters used to describe stream and fish habitat conditions are within reference conditions, with the following exceptions and/or concerns:
    - Fine sediment deliveries and associated water quality parameters are affected from many road surface drainage and erosion problem areas.
    - Large wood recruitment is limited in areas where roads are near streams because of the road presence itself and firewood cutting, although current in-stream wood is within natural ranges
    - Stream segments near recreation sites and roads are at risk of illegal firewood cutting near stream channels and hazard tree removal, which removes the potential for those trees to contribute to woody structures in the channel.

- Stream temperatures on the Lolo NF have generally not been significantly different from reference conditions (Chatel 1993), which appears true for streams in the Butte Lookout analysis area as well.
- Although there has been substantial timber harvest, activities have spanned many decades, and accounting for natural hydrologic recovery and historic stand conditions, current water yields are within natural ranges and not a concern.
- Road densities are high according to Forest and Interior Columbia River Basin assessments.
- Limited numbers of BMPs on roads have been applied, but more upgrades are necessary. Ditches and road surface erosion on NFSR 451 is a primary issue, and there are few buffering devices to buffer sediment from entering stream courses.
- Numerous jammer roads exist (densities up to 25 mi./sq.mi. within small areas), conditions are unknown, and reconnaissance is necessary.
- Eight road-stream crossings are undersized and preclude fish movement.
- Fish populations are influenced by the following limiting factors:
    - Natural and human-related fine sediment quantities
    - Reduced stream productivity from relatively sterile granitic geologies
    - Road-stream crossing barriers and two natural cascade sections (within South Fork Lolo Creek)
    - Competition with exotic species
    - Out of area influences, such as fishing pressure and regulations.

Environmental Consequences

This section addresses the direct, indirect, and cumulative effects of the activities proposed in this analysis on water and fisheries resources. Cumulative effects for water and fisheries resources are considered for West Fork Butte Creek and the South Fork of Lolo Creek, the watersheds most potentially affected by the proposed actions.

Alternative 1 - No Action Alternative

Direct and Indirect Effects

In general, the No Action alternative would maintain the existing condition and relative impacts from the road system on National Forest System land. There would be no sediment or water quality impacts from ground-disturbing activities such as tractor harvesting, new road construction, road improvements, or increased haul traffic. Road decommissioning, including BMPs and culvert replacements, most likely would not occur in the near future, but some of these actions could be implemented in conjunction with other Forest projects and as funds become available.

Human-caused effects primarily result from past timber harvest, grazing, and roads. The existing harvest units have negligible impacts on water resources, other than past effects of timber harvest near riparian areas and effects on soils (reference the Soils report for more detail). The existing road system would continue to contribute sediment to streams

as described in the Effects Common to All Alternatives section below, although old, infrequently-used roads would continue to re-vegetate, reducing the amount of sediment produced and possibly contributed to streams. As previously described, impacts from grazing have been substantively addressed, and streams have responded markedly to changes in management. The future depends on private and National Forest management relative to private allotment interactions and grazing permit requirements.

Relative to natural events and effects, wildfire would likely be the predominant influence with flooding and wind-throw as other possible influences. These events would occur regardless of which alternative was selected, and cannot be predicted with any accuracy. However, not taking action to remove the jammer roads and replace/remove the undersized culverts would likely increase the impact from wildfire when it does happen.

As discussed in the Existing Condition section, water yield influences are within or below natural historic ranges for the existing condition, and they would be expected to remain unchanged unless a natural event occurred, such as a wildfire.

For the entire assessment area, the approximate sediment delivery above natural conditions is estimated at nearly 50 tons (70 cubic yards) per year entering the stream system from road surface erosion, primarily entering at stream crossings (see Tables 44 and 45). This would not be expected to change under the No Action Alternative.

Improving fish passage wouldn't be immediately addressed but could be performed as additional funds and priorities permit.

Cumulative Effects

Cumulative impacts for both past and present influences are discussed in the following section called Cumulative Effects Common to Both Action Alternatives, in the Existing Conditions section, Appendix E and Table 52. In summary all existing conditions and trends are likely to be maintained with some possible improvements in the future.

Forest Plan and Regulatory Compliance

The No Action Alternative partially fulfills regulatory and Forest Plan direction because some conditions are within standards, while others, primarily roads and road-stream crossings, would benefit from improvements, as described.

Direct and Indirect Effects Common to Both Action Alternatives

The following effects assessment is dependent on the implementation of all management and management requirements, which are the same for both Alternatives 4 and 5. The effects of the action alternatives are discussed together because they are very similar; differences are identified.

Direct and indirect effects of Alternatives 4 and 5 discussed in this section include both the short- and long-term influences on:

- sediment delivery and water quality from:
    - timber harvesting
    - log hauling
    - road construction

  - road maintenance and improvement
  - road decommissioning and culvert removal/replacement
- water yield from:
  - tree removal
- fisheries from:
  - culvert removal/replacement
  - herbicide risk

Timeframes for these activities differ and are identified in the following discussions.

Sediment Delivery

Timber Harvesting

Provided that timber harvest BMPs are used and INFISH buffers are in place, erosion and sediment delivery from harvest activities are typically of little to no concern, because in most cases, erosion and sediment delivery does not occur as a result of timber harvest. However, if sediment is generated, sediment travel distances are minimal (i.e. no sediment reaches stream courses). This determination is confirmed by the following assessment.

The primary source of sediment relative to harvesting originates from ground-disturbing activities. By nature of the equipment and technique used, tractor harvest systems have the most potential for ground disturbance, whereas helicopter or skyline logging techniques produce mostly negligible disturbance beyond the soil duff layer. Table 48 below provides the model input values and output results. Input values collected from a weather station in Wallace, ID were used because that station's weather characteristics are most similar to the Butte Lookout analysis area.

Table 48 Modeled Sediment Delivery From Skid Trails in Harvest Units in Alternatives 4 and 5 (Disturbed WEPP Model)

Skid Trail Attributes	Upper Element	Lower Element
Gradient (%)	30	10
Length (feet)	300	300
Cover (%)	10	10
Rock (%)	30	30
Mean Annual Sediment Production using 10 years of climate data	0.0 (tons/acre/year)	

Sediment production values were generated by multiplying the model output by the area of each tractor unit. Harvest activity would not occur within INFISH buffers (i.e., 300 feet from streams) (USDA 1995). Results in Table 49 below indicate that no sediment would be delivered to streams from harvest activities. Also as Table 49 indicates, only improvement type prescriptions (which include group tree selection and variable retention harvest) use tractor harvesting. All other prescriptions would be implemented through skyline or helicopter methods. Additionally all helicopter landings are more than 300 feet from stream courses.

Table 49 Sediment Outputs from Tractor Harvest Units in Alternatives 4 and 5

Silvicultural Prescription	Tractor harvest (acres)	Sediment (tons)
Improvement Cut Mixed Conifer	168	0
Improvement Cut Lodgepole Pine	0	0
Group Tree Selection	0	0
Variable Retention Harvest	0	0

The results of this analysis are also reinforced by the Debaugan Fuels Reduction Project EIS, which is located on the Superior Ranger District of the Lolo NF. This analysis also extensively quantified sediment delivery from harvest operations and also found zero outputs (USDA, 2007).

Log Hauling

Increased traffic levels from log hauling can increase sediment production primarily by rutting and causing road erosion, especially on unpaved and native surfaced roads. Based on Foltz 1999, and Swift 1984 in Burroughs and King 1989, haul road sediment values can double, if roads are allowed to deteriorate. Modeling the effects of haul is difficult because they partially depend on the degree of oversight during implementation activities. Frequently there is very little impact to roads; however other times roads can become “powdered” or are rutted. In this project, BMPs and timber sale requirements require dust abatement on NFSR 451 (the primary haul route) and road closure under conditions that cause rutting.

Consequently, with windrows in place and sediment delivery accounted for in road improvement activities, sediment delivery is considered for approximately 30 crossings that would experience substantial timber haul. With the magnesium chloride and timber sale requirements, sediment delivery values are given a one-time improvement increase (the 0.53 with 85% reduction from windrows), but not doubled, as suggested by the research above, which did not include applying these BMPs. Therefore, for both alternatives, the total modeled short-term increase in sediment from increased traffic levels is 2.4 tons/year (30 *0.53*0.15).

Road Construction

Roads are the primary influence on most of the existing condition and resource values discussed in this section. Alternative 4 proposes about 1.7 miles of new construction with about 1 mile remaining as long-term system roads, and about 0.7 miles being decommissioned after use. Alternative 5 proposes about 0.9 miles of total new construction, with about 0.2 miles remaining in long-term use, and about 0.7 being decommissioned after the project. In addition, under both alternatives, there are potentially about 7 very short (200 to 500 feet) spur roads (i.e., temporary roads) leading primarily to helicopter landing locations.

Using the protocols, assumptions, and values described herein, these new roads have negligible effects on sediment delivery values because they would be located on mid-to upper slope and ridge top positions with no stream crossings and no segments within 300 feet of stream courses. Modeled values for these roads indicate zero sediment delivery based upon road position and distance to streams using the WEPP Road module (Elliot and Hall, 1997).

Road Maintenance and Improvements

Short-Term Effects

Road maintenance and improvements activities would improve road conditions using typical BMPs in addition to road narrowing and graveling in certain road segments. The Transportation Reports provides a detailed list of specific road BMPs and needed maintenance.

Disturbing the road bed material as a result of blading normally results in a short-term increase in sediment (Luce and Black 1999). This increase typically subsides 60-80% within the first two years after blading (Sugden and Woods 2007, Luce and Black 2001, and Megahan 1974). To account for this increase, two times the modeled amount of sediment per crossing was applied (0.53 tons per crossing from pre-project blading, 0.53 tons per crossing from post-project blading). However, slash filter windrows would be applied at major crossings, thus substantively reducing sediment delivery (i.e., windrows are generally 85% or more effective (Seyedbagheri 1996)). Consequently, model outputs are based on 1.06 tons/crossing, reduced to 0.16 tons/crossing to account for windrow buffering. Table 50 displays the modeling results for Alternatives 4 and 5. Although the amount of planned maintenance and improvement work differs by alternative, the number of stream crossings affected largely does not because all of the additional road work proposed under Alternative 4 occurs on upper slopes with no drainage crossings. Alternative 4 does fund an additional culvert replacement, which is addressed in the Culvert Replacement section below.

Table 50 Modeled Sediment Delivery for Proposed Road Maintenance and Improvements

Alternative	No. of Crossings	Short-term Sediment Delivery without windrows (tons/yr)	Short-term Sediment Delivery with windrows (tons/yr)	Long-term Decrease (tons/yr)
Alternative 4	75 (31 with BMPs)	32.9 [31*1.06]	4.9	14.0 [31*0.53*0.85]
Alternative 5	75 (30 with BMPs)	31.8 [30*1.06]	4.8	13.5 [30*0.53*0.85]

In addition to road blading/grading and windrow work, road maintenance work for the proposed action would also include cleaning out culverts, adding additional cross drains and gravel surfacing, and other similar BMP practices on haul routes (reference Transportation Planning maps for road delineations). Additionally, magnesium chloride would be applied to a 6 mile portion of NFSR 451.

Long-Term Effects (10 years)

Although short-term increases of sediment delivery would occur because of sediment disturbance associated with proposed activities, the long-term improvements lead to an overall net decrease in erosion and sediment delivery. Using the cited research, an 85% reduction in existing levels would be realized every year following implementation.

While road density remains moderate to high in many of the watersheds in the analysis area, when accounting for road position relative to water courses, coupled with road-stream crossing improvements and comprehensive BMPs, the action alternatives would result in a net improvement to water resources. However, some of the existing roads, particularly those located close to streams, would continue to impact water quality, stream condition, and watershed hydrology because: 1) they replace land area that could contribute wood and shade; and 2) during substantive climatic events, or other

unforeseen circumstances, roads, especially those sections within 300 feet of drainages, would periodically contribute sediment to the streams.

Road Decommissioning and Culvert Removal/Replacement

Road segments identified for decommissioning are detailed in the Transportation Report. The mean annual sediment reduction associated with decommissioning was analyzed in terms of the number of stream crossings being removed. Although the removal of road segments beyond the proximity to stream crossings also likely reduces long-term sediment contribution, this reduction is minor compared to the accounted stream crossing segments (see Tables 44 and 45).

Road Decommissioning

Road decommissioning would involve short-term disturbance and possible erosion and sediment production. In the long-term, sediment production would be reduced below existing conditions, and reduced hydrologic connectivity would decrease the impact of these roads on surface runoff. Hickenbottom (2001) studied the effects of road recontouring in O'Brien Creek on the Lolo National Forest. Recontoured roads initially had higher surface runoff and higher sediment production than existing road components (e.g., cutslope, fillslope, road center, and road tread). After one year of revegetation, however, volumes of runoff and eroded sediment decreased to near natural slope conditions. These results were obtained under optimal conditions of rehabilitation treatment (e.g., intensive seeding and fertilization); most responses are not likely to be as rapid, although the same trend would be expected, as described by Switalski et al. (2004). Madej (2001) also found reduced sediment yields on logging roads under various treatment scenarios when compared with untreated roads.

Using consistent values described herein, a mean annual sediment contribution of 0.53 tons per crossing was applied to the total number of stream crossings to be removed. Table 51 below shows a summary for proposed treatments under Alternatives 4 and 5, and those to be decommissioned as a "As Funded" Improvement (i.e., actions that the project most likely cannot fund, but would be implemented as other funding became available).

Table 51 Modeled Road Decommissioning Sediment Delivery

Alternative	No. Drainage Crossings Removed/ Rehabilitated	Short-term Sediment Increase (tons/yr)	Long-Term Sediment Decrease in Surface Erosion Inputs (tons/yr)	Potential Long-term Sediment Decrease from fill failure (tons[1])	Potential Total Sediment Reduction (combined surface and fill failure decreases) (tons/yr)
Alternative 1 No Action	0	0	0	0	0
Alternative 4	6	10.8 [6*1.8]	3.2 [6*0.53]	150	153
Alternative 5	5	9.0 [5*1.8]	2.7 [5*0.53]	125	128
"As Funded" Improvements	18	32.4 [18*1.8]	9.5 [18*0.53]	450	460

[1] Calculated using 50% of estimated fill volume of 25 tons for a one time event

Summarizing Table 51, under Alternatives 4 and 5, six and five culverts would be removed, respectively, totaling nearly 11 and 9 tons of sediment delivery as a result of road decommissioning implementation. In the long-term, 3.2 and 2.7 tons/year would be

reduced because of crossing removal, which equates to the short-term negative influence balancing with the long-term gain between three and four years. “As funded” road decommissioning would result in an initial 32.4 tons delivered, but sediment in the long-term would be reduced by approximation of 9.5 tons annually– taking an estimated 3.5 years to balance short-term impact with long-term gain.

Culvert Removal

Culvert removal involves a short-term disturbance to channels at the crossing site with an associated release of sediment to a stream during and immediately after removal. Seyedbagheri (1996) cites a study in the Horse Creek Study Area in central Idaho in which sediment increases were observed with new road construction and culvert installation. Sediment concentration levels returned to preconstruction levels shortly after construction, except during storms when sediment loads were 100 to 1,000 times higher than normal. A year after construction, sediment loads during storms were about 10 times higher than normal. With care, however, the amount of short-term impact may be quite small. Using required BMP practices on the Lolo NF, an intensive monitoring effort on Siegel Creek on the Plains/Thompson Falls Ranger District was conducted. This effort aimed at understanding sediment delivery magnitudes both during and after a 72-inch culvert removal project. After stream diversion and removal of all fill around the culvert, there was an unavoidable pulse of increased sediment production as the culvert was pulled from the channel. Within approximately 24 hours afterward, sediment levels decreased and totally returned to pre-removal levels. Total sediment introduced to the stream was 1-2 cubic yards from a total fill removal of 500 cubic yards (USDA-FS, Lolo National Forest, 1999).

Culvert Replacements

In addition to contributing sediment from road surface erosion at stream crossings, undersized culverts at road stream crossings pose a potential risk of sediment contribution in the event of road fill failure. Persistent channel and road fill scour is also a common sediment-related water quality issue with undersized crossing structures. By adequately sizing road-stream crossing structures, the risk of potential sediment contribution from culvert failure has been almost eliminated. Current Regional standards for crossing replacements require a stream simulation design approach, which means that the natural channel dimension, gradient, bedform, and substrates are mimicked to the extent possible. In addition, this approach also provides for the mandatory INFISH requirement of providing for the Q100 flow magnitude without ponding water upstream from the culverts.

The total amount of potential sediment contribution from culvert failure at the proposed replacement crossings is estimated in Table 52 below. Short-term sediment values are the same as those described in the road decommissioning; 2.5 tons/crossing. The volume in cubic yards of affected fill was calculated based on field measurements and then converted to tons. Fifty percent of the fill volume was used as a reasonable value in balancing the sediment budget because in the event of crossing failure, typically only a portion of the fill is eroded. Short-term effects amount to 5 and 2.5 tons, respectively for Alternatives 4 and 5. “As Funded” improvements are likewise represented below.

Table 52 Sediment Delivery Effects from Replacing Stream-Crossing Structures

Alternative	No. of Culvert Replacements	Estimated Fill Volume Eroded during crossing failure (tons)	Short-Term Sediment Contribution from Replacement (tons)	Net Sediment Effects[1]
Alternative 4	2	Rd 971: [(8'x24'x30')/(27)(2)(1.4)]: 76 Rd 16726: [(5'x14'x20')/(27)(2)(1.4)]: 20	5	1.1 ton reduction 86 ton reduction
Alternative 5	1	971: 76	2.5	0.5 ton reduction 74 ton reduction
"As Funded"	4	902: 20 874: 20 899: 30 1468: 25	10	2.1 ton reduction 65 ton reduction

1 Annual surface erosion using 50% of fill volume measured in tons for a one time event

Sediment Delivery Summary

Table 53 and Figure 4 provide a summary of the modeled short-and long-term effects from roads and roads activities as described above for Alternatives 1, 4 and 5, as well as all "As Funded" Improvements. As the table indicates, some actions contribute sediment in the short-term (indicated by "+" sign), but result in long-term sediment decreases (indicated by "-" sign).

Table 53 Summary of Modeled Short-and Long-Term Sediment Delivery Effects From Roads and road Activities (Sediment Measured in Tons)

	Existing Roads (tons/year)	Project Harvest (+)	Project Landings (+)	New Road Construction (+)	Road Decom. Short-Term (+) Long-Term (-)	Crossing Replacement (+/-)	Road Maint. & Improvements (+ short-term) (- long-term)	Haul Route Traffic (+)	Total (10 year period)	Change from Existing (10 year period)	Percent Change from Existing (10 year period)
Alternative 1	49.2	0.0	0.0	na	0.0	0.0	0.0	0.0	49.2	0	0
Alternative 4	49.2	0.0	0.0	0.0	+10.8 - 3.2 - 150	+5 - 1.1 - 86	+ 4.9 -14.0	2.4	-145.4	492.0 to 346.6	- 30%
Alternative 5	49.2	0.0	0.0	0.0	+9.0 - 2.7 - 125	+2.5 - 0.5 - 74	+4.8 -13.5	2.4	-113.4	492.0 to 378.6	- 23%
"As Funded" Improvements	49.2	0.0	0.0	na	+32.4 - 9.5 - 460	+10 - 2.1 - 65	0.0	0.0	-73.6	492.0 to 418.4	- 15%

Short-term is generally expected to be 1-5 years depending on activity. Totals are summarized by the following years of short-term influence over a 10 year period. Episodic failure estimates are displayed in bold text, but not displayed in the long-term assessment.
Timber operations (5 years); new road construction (2 years); haul (5 years); road maintenance and improvements (2 years); Road decommissioning (1 years); and crossing replacement (1 years)

This analysis demonstrates that the proposed project would result in a total short-term increase in sediment of 37.6 and 33.1 for Alternatives 4, and 5, respectively. The short-term increase would be a one-time occurrence, whereas the long-term decrease would persist for some time. For estimation purposes, 10 years is used as a reasonable time period to display effects. Therefore, net sediment within the drainage would reduce by

30% (146 tons), 23% (113 tons), and 15 % (74 tons), for Alternatives 4, 5, and “As Funded” Improvements, respectively.

Estimates for sediment contributions in the event of road crossing failure are also shown in Table 53 (i.e., “episodic failure” values (“-“) in bold text), but are not accounted in the summaries because of the large uncertainty regarding when failures would occur. Failure is however considered a moderate to high probability; therefore, sediment reduction estimates provide a complete context of the positive effects that culvert removal and replacement efforts would have on the long-term watershed and fisheries condition.

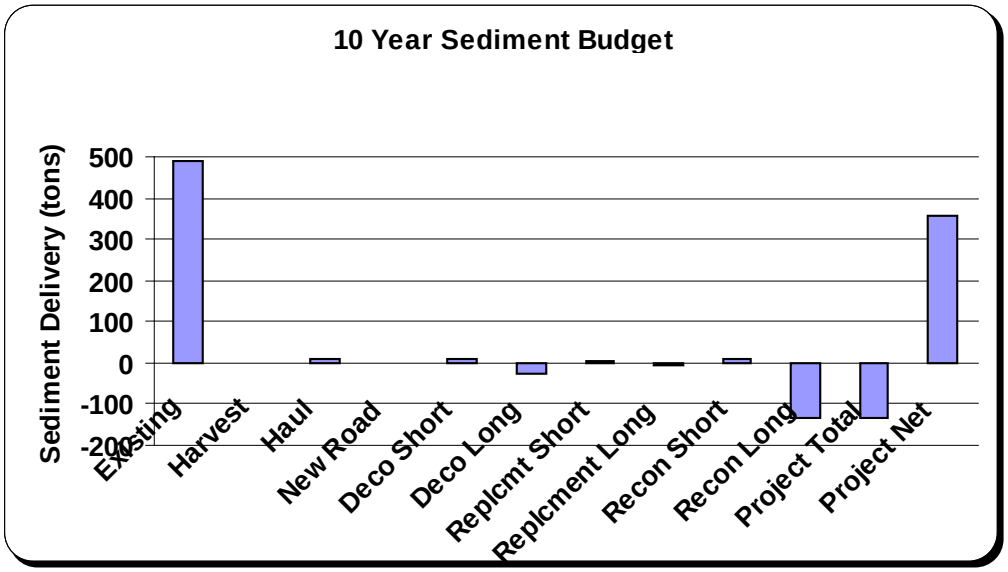

Figure 4 Modeled existing, and short-and long-term effects for Alternatives 4 and 5

Note: The differences in sediment delivery for Alternatives 4 and 5 when displayed at this scale are indistinguishable.

Best Management Practices

Two different road scenarios, which represent two different types of roads within the analysis area, were modeled using the WEPP: Roads model to evaluate the effectiveness of road BMPs and their relationship to road use. The first model run represents a typical road that is found inside the analysis area which consists of: moderate gradients (~4%), low to no use (i.e., administrative use), moderate width (~16’), inadequate drainage spacing (~800’), mid-slope location, and a gravel surface. This scenario was run once to show a relative existing condition and then again to show the changes associated with increased traffic volume and decreased drainage spacing (~350’). The result demonstrates the need for BMP implementation prior to haul. The existing condition run models 771 lbs and 484 lbs (per mile of road) of sediment production to nearby streams for low and no traffic volumes, respectively. When the same scenario is run with a heavy traffic volume (i.e., due to log haul) and increased frequency of road and ditch drainage (BMPs) the modeled sediment delivery was 811 lbs per mile of road. This model only considers BMPs associated with road and ditch drainage frequencies and does not include the use of road management requirements

such slash filter windrows. Again, this demonstrates the importance of BMPs and the need for their implementation prior to an increase in road use.

The second scenario that was modeled is that of a heavily-used riparian road segment that has the following characteristics: steep slope (~8%), heavy use (open to public use), wide width (~20'), inadequate drainage spacing (~800'), close proximity to stream channels, and native surface (NFSR 451 is graveled but the gravel is severely worn). The modeled output of the existing condition resulted in approximately 3.9 tons of sediment delivery per road mile. When the road was narrowed to 16 feet wide (the only parameter changed) the associated sediment production is approximately 20% less than the modeled existing condition. When the road was narrowed to a 16-foot width, drainage frequency was decreased (~350'), and gravel surfacing was added, the result was a sediment reduction to approximately 0.6 tons/road mile. This is an approximate 85% reduction and this does not include potential mitigation gained with slash filter windrows or dust abatement.

This modeling was not meant to determine how much sediment is potentially entering the stream but to demonstrate the effectiveness of BMPs relative to stream proximity and changes in traffic use. Thus, BMPs on mid-slope, low volume use roads generally will offset a short-term impact associated with increased haul and BMPs on roads paralleling or in close proximity to streams may offset more than the impact. This modeling supports the need to implement all designated BMPs on the haul routes prior to log haul.

Water Yield

Because tree removal can potentially increase water yields, a thorough assessment of canopy reduction effects was conducted and is explained in detail in the Project File. Summarizing the findings, the Equivalent Clearcut Area (ECA) of the analysis area is 8.6%, which is well below values referenced by King (1989), Cheng (1989) and Burton (1997). Runoff increases above natural ranges would not occur, which is reinforced by accounting for historic stand conditions where on average, in a large watershed context, non-stocked and young tree ages accounted for nearly 39% of the area. Consequently, these alternatives do not negatively influence natural water yield functions.

Fisheries

Culvert Removal/Replacement

Fish habitat access would be positively influenced by both action alternatives, resulting in approximately 9.25 miles of improved access. Currently, there are eight culverts that are acting as partial barriers obstructing approximately 11.3 miles of potential fish habitat (see Table 46). Replacing and removing the two structures described in the action alternatives would account for approximately 82% of the impeded stream miles within the West Fork Butte Creek watershed. Removing the West Fork Butte Creek barrier (Culvert #971) is important because it is a partial barrier that is located low in the watershed. The significance of this is that it is only a barrier during higher spring flows; as flows drop throughout the summer it becomes less of a barrier. This likely results in a "screening" of native fish species. Rainbow trout generally move before high flows and probably have reasonable access during the migration period. Brook and brown trout move in the late summer when stream flows are low and passage is likely. However,

westslope cutthroat trout move during high flows, and bull trout have been found to move as flows are dropping from the peak, all during times of unlikely passage.

Aquatic Herbicide Risk Assessment

The Lolo NF uses the aquatic herbicide risk assessment procedure recommend by Rice (1990). This process determines the potential concentration in parts per million (ppm) of herbicide that potentially could enter a stream channel. This concentration is then compared to the lethal and safe concentrations for the target species. Lethal doses are laboratory-derived and usually measure the concentration of chemical that it takes to exterminate fifty percent of the target population in a 96-hour time period (96-hr LC50). Obviously managers do not desire herbicide application to result in any mortality of any target species. To ensure this non-lethal application, the 96-hr LC50 is multiplied by 1/10 to obtain a “safe” level for the target organisms. This “safe” level becomes the threshold used to measure modeled herbicide concentration. Adjustments are made to application location and rates accordingly, if necessary.

The results of this analysis suggest that the use of Milestone® at the prescribed rates would have a very low aquatic risk and not result in concentration levels of concern for aquatic organism within the West Fork Butte or South Fork Lolo watersheds. See Table 54 for the results of the analysis and Appendix WF-2 for a thorough discussion of analysis procedures.

Table 54 Aquatic Herbicide Risk Assessment

Analysis Unit	Acres	Total for West Fork Butte Creek (parts per million)	LC50/10 (Used as the Safe Concentration level where there is a lack of information of long-term exposure)(mg/L)
Infiltration Dominated Sites (e.g., harvest units, ecosystem maintenance burn units, etc.)	161	.07	10
Infiltration Dominated Sites (e.g., “As Funded” road decommissioning)	81	.03	
Runoff Dominated Sites (e.g., roadsides)	209	.58	
Total Timber Sale Foreseeable Road Decommissioning Total	270 81 351	0.65 0.03 0.68	

Cumulative Effects Common to Both Action Alternatives

Table 55 below and Appendix C provide additional discussion, summary, and a comprehensive list of past, present, and reasonably foreseeable influences. Past and present influences are discussed within relative sections of this document for all alternatives, as they are considered baseline conditions for which the proposed activities are evaluated. Reference the relative section and/or appendix for detailed discussion by subject area.

The boundary of the cumulative effects area is the hydrologic divide of the South Fork Lolo Creek watershed, of which the project area of West Fork Butte Creek is a tributary. This boundary area was used because it corresponds to an area by which effects from the action alternatives may be measured. A boundary area larger than this would likely

dilute any potential effects from the action alternative and not provide a setting relative to the project area.

Cumulative effects include past, present, proposed and reasonably foreseeable actions, regardless of landownership. As seen in Table 39 the West Fork Butte Creek and South Fork Lolo Creek watersheds are predominately on National Forest System lands, which makes activities in these watershed easier to track and anticipate.

Natural processes and past actions account for the existing condition in the analysis area (see baseline discussions in Existing Condition section). Activities have varied from road building, road maintenance, grazing, timber harvest, weed spraying, ditch diversions, recreational use, fire suppression, ranching, farming, and many other projects that have occurred within these drainages. Recent actions worth noting include: rehabilitation of the Ward Lode mine; riparian road decommissioning in the lower reaches of West Fork Butte Creek; positive changes in grazing practices on the South Fork/East Fork grazing allotment; and opening access to the South Fork Lolo Creek by installing a fish ladder and screen on a diversion dam.

Present actions include road and trail maintenance, weed spraying, dispersed camping and recreational uses, grazing, farming, fire suppression, irrigation diversions, and watershed and fish population monitoring.

Proposed actions are described in the direct and indirect effect section along with timeframes describing the duration of the activities.

Foreseeable actions consist of continued road and trail maintenance, weed spraying, dispersed camping and recreational uses, land acquisition of a Montana Department of Natural Resources (DNRC) parcel by the Lolo NF within the lower reaches of West Fork Butte Creek watershed, grazing, farming, irrigation diversions, and watershed and fish population monitoring.

Stream channels will continue to be affected by a wide range of natural and human influences. Except for the lower extent, the South Fork of Lolo Creek will continue to be undeveloped, while sections of the other streams will be subjected to timber management, recreation, and private, agricultural influences. The trend in stream health and awareness of significance of water resource protection by all landowners is positive at this time, and hopefully will continue.

Fire and wildfire are also past, present and foreseeable actions. Potential effects from wildfire are highly variable and largely dependent on climatic conditions and the specific setting. Therefore, predicting the future behavior of fire in riparian areas is speculative and cannot be forecasted with precision, particularly when those impacts may not occur for decades. Localized temporal and unpredictable factors such as winds, humidity, and time of day combine with fuel loads and topographic features to determine how a particular area will burn. However, in most situations fire is a natural and necessary component in watershed processes and condition.

Prescribed fire operations (e.g., ecosystem maintenance burning) would likely cause incidental fire mortality of larger trees and is acceptable. Positive impacts would occur because fire is an integral part of the process for adding large woody debris to stream systems. Woody material gradually begins to accumulate in stream channels from the undercutting and blowdown of fire-killed trees within a 30 meter corridor of either side of

the channel (Minshall, et. al. 1989). Large woody debris is not only important for creating fish habitat, it becomes important for creating energy dissipation and sediment traps in the smaller non-fishery streams. Fire has also been well-documented to temporarily increase nutrient loading into streams (Minshall, et. al. 1989; and Bayley, et. al. 1992). This is usually done as nutrients are leached out of the ash and soil layer and transported to streams. This nutrient loading is a temporary increase and decreases as vegetation is re-established. The associated risks that accompany these burning projects are believed to be small, as the amount of fire being proposed is considered very small. In all cases, because of the low intensities of these fires, it is expected to have immeasurable effects on sediment production and stream shading. The overall effect of the proposed fire management to streams is positive.

Table 55 Summary of Cumulative Effects for Both Action Alternatives

Action	Contribution and Possible Trend
Natural Events	
Mountain pine beetle epidemic	Most likely will have some impact, although not likely to cause negative effects to water resources because the watershed conditions and soil moistures are such that decreases in water uptake and interception are not likely to lead in water yield relations that would cause negative runoff magnitude or timing influences.
Wildfire	Will occur and impact the drainages in varying degrees. Although some conditions may lead to short-term increases in sediment delivery, except where roads may exacerbate influences, wildfire is a desired event that positively influences water resources.
Flooding	Same as wildfire comment above.
Windthrow	Same as wildfire comment above.
Anthropogenic Events	
Wildland Fire Suppression	Has likely affected water resources in relation to possible decrease in water yield as increases in stand density have greater water uptake and interception, although this is not negatively affecting water resources. Continued suppression could result in higher intensity wildfire, which could temporarily cause conditions that lead to greater sediment delivery than under natural fire regimes – although even in high intensity scenarios, negative conditions tend to be short-term, or "pulse" in nature, and long-term beneficial to water resources.
Timber Harvest	Past harvest has most likely influenced water yield, but streams do not indicate impacts from excessive increases. Tree recruitment to streams, and thus habitat and energy dissipation, has been reduced in areas where roads and thus timber removal has occurred near streams. Except for illegal wood cutting within 150 feet of streams, future trends are for increased tree recruitment as INFISH buffers are followed.
Pre-commercial Thinning	Will likely occur, with effects minor, as stands are managed closure to natural basal areas.
Prescribed burning	Will occur, with positive effects to water resources as this action more closely mimics natural events.
Planting	Will likely occur to some extent with little to no effect on water resources.
Road Construction	In the past has negatively influenced water resources, as described herein. Impacts will continue to reduce however, as road improvements and reductions are made. Future trends are for little to no road construction, with effects similar to what is described herein.
Land Exchange	Not likely in this drainage. Land ownerships will likely continue as they are presently.
Grazing	As described herein. Substantive negative impacts in the past, with great improvement. Trend is dependent on future management.
Utilities	No known utility lines are currently or have previously existed and there are no known plans in the future.
Watershed Improvements	Will continue with positive impacts as long as human infrastructure exists in the drainages.
Road Improvements	Will continue with positive impacts as long as human infrastructure exists in the drainages.
Winter Recreation Snowmobiling	Snowmobiling, cross-country skiing: Effects are not likely or minor and localized. Possible effect of sediment delivery from travel during spring breakup conditions, which effects will rely on road management to avoid impacting to existing roads.
Summer Recreation	Effects are not likely.

Action	Contribution and Possible Trend
Firewood and other miscellaneous product gathering	Effects are not likely, and are minor and localized; firewood cutting in RHCAs likely occurs along roads and at dispersed camping areas.
Unauthorized ATV use	Likely is beginning to affect water quality by extending the road network; ATV trails are not managed and do not have BMPs. Future trend is for more enforcement to avoid negative impacts.
Mining	Although negative impacts have occurred in the past, the location and condition of the known mineral interests will most likely not cause future concern or impact because it most likely will not be mined again, and if it is, the deposit is on the top of a ridge and future management will likely keep impacts minimal.

In addition, Table 56 below summarizes specific short-and long-term project influences and associated findings of this analysis for the cumulative effects area for Alternatives 4 and 5.

Table 56 Year Summary of Primary Direct and Indirect Road Impacts – Alternatives 4 and 5

Primary Influence	Existing Condition (tons)	Alternative 4 Short-term Impact (tons in first 5 years)	Alternative 4 Long-term Impact (10 years)	Alternative 5 Short-term Impact (tons in first 5 years)	Alternative 5 Long-term Impact (10 years)
Sediment Delivery	Road-stream crossings and riparian road segments have primary influence at 492 tons over 10 years.	38 for sediment deliveries associated with road reconstruction, decommissioning, culvert replacement, timber haul, etc.	145 ton reduction from projected 492. Equates to 30% reduction from existing conditions.	33 for sediment deliveries associated with road reconstruction, decommissioning, culvert replacement, timber haul, etc.	113 ton reduction from projected 492. Equates to 23% reduction from existing conditions.
Habitat and Nutrient Connectivity	Currently 8 major stream crossings are fish passage barriers	About 5 tons of sediment is projected to enter the stream during replacement activities.	This alternative replaces the highest priority and most expensive crossing, establishes fish passage and fulfills accommodation of the Q100 design flow.	About 5 tons of sediment is projected to enter the stream during replacement activities.	This alternative replaces the highest priority and most expensive crossing, establishes fish passage and fulfills accommodation of the Q100 design flow.
Stream and Floodplain Encroachment	South Fork: 14% road <300' 6% road <125' West Fork: 39% road < 300' 19% road <125'	Short-term sediment deliveries would increase from culvert replacement and reconstruction activities. Road positions remain unchanged.	Road maintenance and improvements would decrease sediment deliveries. Roads would remain in same locations.	Short-term sediment deliveries would increase from culvert replacement and reconstruction activities. Road positions remain unchanged.	Road maintenance and improvements would decrease sediment deliveries. Roads would remain in same locations.
Aquatic Habitat	Within reference conditions as	Remain within reference conditions with	Remain within reference conditions with	Remain within reference conditions with	Remain within reference conditions with

Primary Influence	Existing Condition (tons)	Alternative 4 Short-term Impact (tons in first 5 years)	Alternative 4 Long-term Impact (10 years)	Alternative 5 Short-term Impact (tons in first 5 years)	Alternative 5 Long-term Impact (10 years)
	described.	some short-term elevations of sediment delivery.	long-term improvements in sediment delivery and connectivity.	some short-term elevations of sediment delivery.	long-term improvements in sediment delivery and connectivity.
Downstream Influences on Water Quality and Habitat	Elevated fine sediment levels and turbidity as fine sediment is mostly transported through the higher gradient streams to downstream lesser gradient habitats beyond the assessment area.	Some short-term increases to delivered sediment resulting from improvement activities.	Long-term reductions in delivered sediment to downstream waters and habitats.	Some short-term increases to delivered sediment resulting from improvement activities.	Long-term reductions in delivered sediment to downstream waters and habitats.

Forest Plan and Regulatory Consistency

Provided that all management and management requirements were fulfilled, Alternatives 4 and 5 are consistent with all Forest Plan, INFISH, and all other regulatory standards and guidelines. The proposed activities would lead to a reasonable improvement in existing conditions which are currently negatively impacted. All other water resource conditions that are currently within desired future conditions, as compared to reference conditions, would be maintained.

Summary of Effects Relative to Key Issues and Questions

Table 57 below addresses project effects specific to issues and concerns identified and discussed previously.

Table 57 Summary of Effects Relative to Key Issues and Questions

Key Question or Issue	Project Effect
1. Will prescribed fire, logging, and road decommissioning degrade water quality, mainly by increasing sediment delivery to streams?	Prescribed fire and timber removal will have no short- or long-term effect on sediment delivery. Road decommissioning will create sediment delivery within 1-2 years following implementation. Long-term sediment delivery will be reduced, equating to a net overall reduction.
2. Several streams in the project area are on Montana Water Quality Limited streams for a variety of reasons. How will the proposed management activities affect water quality?	All actions will improve long-term water quality conditions with some short-term impact.
3. Will closing or decommissioning roads cause more damage to resources than just leaving them in their	Decommissioning roads creates some short-term negative influences on some roads, but long-term, multiple resource

Key Question or Issue	Project Effect
existing state and allowing them to vegetate naturally?	benefits (i.e. long-term chronic and potential episodic sediment reduction, wildlife, diverse recreational opportunity, fish passage, etc.) substantively outweigh any negative influences.
4. In what condition is aquatic habitat?	This is described in the Existing Conditions section and appropriate appendices.
5. What management activities have and/or are influencing the quality of aquatic habitat?	Many management activities influence aquatic habitat. Primary influences are described throughout this report. Please reference specific sections and appendices for specific detail.
6. The bull trout and westslope cutthroat trout are currently listed as sensitive species in Region One. What is the fish population status and what management influences are affecting fish viability?	Key factors for both action alternatives are replacement of culvert barriers with a structure that will accommodate fish passage and road reconstruction of the NFSR 451 that will reduce direct sediment entry into Marshall and W. Fk. Butte Creeks.
7. What activities can be accomplished within the watershed area to remedy or mitigate negative watershed and aquatic influences?	Road decommissioning and crossing rehabilitation, culvert replacements, road width reduction, road surface drainage improvement, sediment delivery buffering devices, continued sensitive grazing allotment management, fulfillment of no-activity riparian habitat conservation areas, wildfire, prescribed fire and/or timber harvest returning natural timber stand ranges and conditions. This project attempts to address all of these to the extent possible given multiple resource and social issues.
8. How does the proposed project affect the fishery and aquatic habitat?	Fishery and aquatic habitat will benefit from the reconstruction of NFSR 451 road segments as it will result in a net decrease in sediment delivery to Marshall and W. Fk. Butte Creeks.
9. There are extensive road networks and crossings throughout the analysis area. What are the impacts from roads and what can be done to eliminate or reduce any negative effects?	This is discussed extensively in the Existing Conditions, Environmental Consequences, and specific appendices.
10. Direct sediment routing from road surfaces and ditches to stream channels have been identified in many locations. What can be done to eliminate or reduce this negative influence to water quality and fisheries habitat?	Road closure, decommissioning, and road improvements all address this and are discussed extensively in the Existing Conditions, Environmental Consequences, and specific appendices.
11. Water yield increases above natural have been a concern in the past. What is the current condition relative to water yield, and what impact will the proposed activities have on water yield?	Existing and proposed activities will not negatively influence water yields. See appropriate sections and Project File, Item WF-7.
12. There are additional opportunities to improve road conditions, improve riparian and bank stability problems, increase large woody debris and decrease sediment levels throughout the analysis area. What are these opportunities, where are they located, and what is being done to address them?	See bullet item 7 above and also addressed in many areas throughout the report and appendices.
13. There has been extensive cattle grazing on both private and public lands within these watersheds. What are the current impacts from grazing and what is being done to eliminate or reduce these impacts?	Grazing is not negatively affecting water or stream resources, as conditions have markedly improved. Reference the Existing Conditions discussion on grazing for additional detail.

The following items address specific project consequences to previously bulleted items summarizing the existing conditions (reference the Summary in the Existing Conditions section).

- The South Fork of Lolo Creek is listed by the Montana Department of Environmental Quality (DEQ) as being “Water Quality Limited”. Alternatives 4

and 5, and the “As Funded” Improvements would improve conditions relating to the impairment status. Alternative 1 would have no effect.

- Sensitive soils are addressed in specific management and management requirements. All actions included in Alternatives 4 and 5 and the “As Funded” Improvements consider these conditions.
- Stream condition indicators show marked improvements and Riparian Management Objectives are achieved. Alternative 4 and 5 and the “As Funded” Improvements would continue the trend of improvement. Alternative 1 would maintain past improvements.
- Parameters used to describe stream and fish habitat conditions are within reference conditions, with the following exceptions and/or concerns:
    - Fine sediment deliveries and associated water quality parameters are affected from many road surface drainage and erosion problem areas. Alternative 1 maintains these conditions. Alternatives 4 and 5 and the “As Funded” Improvements would substantively reduce negative fine sediment influences.
    - Large wood recruitment is limited in areas where roads are near stream because of the road presence itself and firewood cutting, although current instream wood is within natural ranges. All alternatives and the “As Funded” Improvements would maintain this situation because no activities are planned within riparian habitat conservation areas.
    - Stream segments near recreation sites are at risk of illegal firewood cutting near stream channels and hazard tree removal, which remove the potential for those trees to contribute to woody structures in the channel. All alternatives would maintain this situation as the project does not address this.
- Stream temperatures on the Lolo National Forest have generally not been significantly different from reference conditions (Chatel 1993), which appears true for streams in this assessment area as well. All alternatives would maintain this condition.
- Although there has been substantial timber harvest, activities have spanned many decades, and accounting for natural hydrologic recovery and historic stand conditions, water yields are within natural ranges and not a concern. Alternatives 4 and 5 and the “As Funded” Improvements would maintain this condition.
- Road densities are high according to Forest and Interior Columbia River Basin assessments. Alternatives 4 and 5 and the “As Funded” Improvements would reduce road densities, but they remain high according to ICBEMP guidance.
- Limited numbers of BMPs on roads have been applied, but more and upgrades are necessary. Ditches and road surface erosion on the Elk Meadows Road is a primary issue, and there are few buffering devices to buffer sediment from entering stream courses. Alternative 1 would maintain this situation. Alternatives 4 and 5 would both implement substantive road improvements.

- Numerous jammer roads exist (densities up to 25 mi./sq. mi. within small areas), conditions are unknown, and reconnaissance is necessary. Alternatives 1, 4, and 5 would maintain this condition. The “As Funded” Improvements would perform adequate reconnaissance and remedy negative influences.
- Eight road-stream crossings are undersized and preclude fish movement. Alternative 1 would maintain this condition. Alternatives 4 and 5 would remedy one of these crossings, and the “As Funded” Improvements would remedy all of these over time by priority.
- Fish populations are influenced by the following limiting factors:
    - Natural and human-related fine sediment quantities. Alternative 1 would maintain this condition. Alternatives 4 and 5 and “As Funded” Improvements would substantively improve this condition.
    - Reduce stream productivity from relatively sterile granitic geologies. No actions included in any alternative would affect this natural condition.
    - Road-stream crossing barriers and two natural cascade sections. Alternative 1 would maintain this condition. Alternatives 4 and 5 would remedy one of these crossings, and the “As Funded” Improvements would remedy all of these over time by priority, with the exception of the two natural cascade sections.
    - Competition with exotic species. Alternative 1 would maintain this condition. Alternatives 4 and 5 would aid native fish by allowing them to express their full life histories.
    - Out of area influences, such as fishing pressure and regulations. No actions included in any alternative would affect this condition.

Soils

Forest Plan Direction and Other Regulatory Framework

Lolo National Forest Plan provides Forest-wide management direction regarding the soil resource.

Forest Standard 18 directs, “All practices will be designed or modified as necessary to maintain land productivity” (Lolo National Forest Plan, page II-12).

Forest Standard 50 states, “During road design, special emphasis will be placed upon minimizing soil movement…” (Lolo National Forest Plan, page II-18).

Management Area 16 (Lolo National Forest Plan, page III-71)

> **Standard 4**: “Ground vegetation and soil will be left undisturbed immediately adjacent to all streams and draws.”
>
> **Standard 5:** “Yarding methods will be used that minimize or eliminate soil disturbance in the riparian area.”

Forest Plan Monitoring Item 4-3 defines a threshold of 20 percent reduction in “productivity”, as measured by soil disturbance/displacement, to trigger further evaluation (Lolo National Forest Plan, page V-10).

Lolo National Forest, Land Systems Inventory - This document does not have a regulatory purpose. Rather, as the document's objective states, "This survey is best used as a tool for identification of areas that require special management treatment or at least on-site evaluation."

Region 1 Supplement 2500-99-1 (Region 1 Soil Quality Standards): These standards require that soil properties and site characteristics be managed in a manner consistent with the maintenance of long-term soil productivity, soil hydrologic function, and ecosystem health. The Soil Quality Standards define 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 timber sale. It also states that in areas where less than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects of the current activity following project implementation and any needed restoration activities must not exceed 15 percent. In areas where more than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and needed restoration activities should not exceed the conditions prior to the planned activity and should move toward a net improvement in soils quality. Note that there are no Regional or Forest standards/guidelines for the amount of area impacted within a project area (e.g., the Butte Lookout Project area).

Analysis Area Boundary - Geographic and Temporal

The Butte Lookout Analysis Area lies within the West Fork Butte watershed including its principle tributaries Marshall Creek and Cooper Creek. West Fork Butte Creek itself is a tributary to the South Fork of Lolo Creek. Soil parent materials in the project area vary from precambrian belt rocks to schist, gneiss, and granite. The area primarily to the east of Cooper Creek is where the more sensitive soils derived from the Idaho Batholith are encountered. The western portion of the analysis area has quite stable soil derived from weakly weathered belt rocks.

The sensitive soils east of Cooper Creek are of two distinct types. The more extensive form is soil whose parent material is predominately micaceous shists and sandstones. Soils are non-cohesive sandy loams and silt loams containing a high amount of mica. They occur on both steep and moderate relief mountain slopes and some glaciated landforms. Soils containing mica may be unstable on certain steep slopes particularly if there is abundant subsurface water. Micaceous soils are also very erosive.

The other sensitive soil is derived from weakly consolidated, weathered granitic rock ("grus"). These soils are coarse sandy loams and loamy sands containing large amounts of fine gravel-sized particles which can often be easily crushed with the fingers. This type of soil is also prevalent in the Lolo Hot Springs area and is visible from Highway 12. "Decomposed" granitic soils are also very erosive and, because they have a low water holding capacity, disturbed areas are difficult to revegetate.

In addition to both these soil types being very erosive, they generally have low bearing capacity, very high compaction hazard, and very high erosion hazard. Steep slopes, high water tables, high drainage densities, and high annual precipitation magnify the potential for erosion if the soil mantle is disturbed. This potential erosion is in the form of surface erosion and minor slumping, not mass failures. See Table 58 for soil descriptions and proposed activities.

The temporal scale for assessing soil resource environmental effects includes both short- and long-term impacts. For the purposes of this analysis, short-term effects are defined as those that occur within about 10 years following proposed vegetation treatments. Long-term effects are defined as those that occur within about 10-20 years or more following proposed vegetation treatments.

Analysis Methods

Following direction in the Northern Region Soil Quality Standards, the scale of analysis for soils is the “activity area”. For this project, activity areas will be treatment areas, either harvest units, noncommercial vegetation treatment units, or prescribed burn units. Activity areas are a subset of the larger project area.

The soil analysis process followed is described in “Lolo NF Soil Characterization Assessments: 2006 Preseason Field Crew Training, Calibration and Standardization” and “Procedure for Analyzing the Effects of Previous and Proposed Activities on Soil Resources” (Project File, Soil section). Field sampling during the 2007 field season was slightly modified from the 2006 season. The 2007 techniques are described in, “The 2007 Northern Region Soil Quality Monitoring Protocol.”

The soil analysis describes the current soil condition and establishes the base from which detrimental soil effects caused by implementation of the proposed management activities can be evaluated.

Detrimental soil effects are the result of detrimental soil disturbances. Detrimental disturbances are defined in Forest Service Manual, R-1 Supplement 2500-99-1 as the condition where established soil quality standards are not met and the result is a change in soil quality. This standard also expects soil quality (and productivity) to be maintained when at least 85 percent of an activity area is maintained in satisfactory soil conditions.

Forest Service Manual, R-1 Supplement 2500-99-1, defines the Regional soil quality guidelines in terms of detrimental soil disturbance, which include:

- **Compaction**. Compaction is detrimental when natural bulk density increases more than 15 percent.
- **Rutting.** Wheel ruts at least two inches deep in wet soils are detrimental.
- **Displacement.** Detrimental displacement is the removal of one or more inches (depth) of any surface soil horizon, usually the A horizon, from a continuous area greater than 100 square feet.
- **Severely-burned Soil.** Physical and biological changes to soil resulting from high intensity burns of long duration are detrimental.
- **Surface Erosion.** Rills, gullies, pedestals, and soil deposition are all indicators of **detrimental surface erosion.**
- **Soil Mass Movement.** Any soil mass movement caused by management activities is detrimental.

It is possible to have soil disturbances that are not detrimental. For example, loss of less than one inch of topsoil over less than 100 square feet is not a detrimental soil disturbance.

To assess current conditions relative to Regional Soil Quality Standards, field investigations were conducted during the 2006 and 2007 field seasons. First a soil map of the project area displaying the integration of Land Systems Inventory Mapping Units and proposed treatment activities was produced.

Based on project area reconnaissance and previous treatment area sampling, compaction and displacement are the only indicators of detrimental soil condition currently observable in the project area. Indicators of the four remaining detrimental disturbance criteria are lacking because of either nonexistence or natural recovery over time.

As stated earlier, the scale of analysis for soils is the “activity area”. For this project, activity areas are treatment areas, harvest units, noncommercial cutting units or areas of prescribed burning. Comparisons to the standard were based on the proposed activity and the combination of the proposed and foreseeable activities’ potential to exceed the 15 percent detrimental condition standard. Any activity area where the combination of past and proposed effects would exceed the 15 percent detrimental condition standard would be rehabilitated to less than the 15 percent standard.

Most of the effects analysis is based on procedures followed for assessments of past management activities on the Lolo, Bitterroot, and Flathead National Forests and reports of broader-scale scientific studies. Assessments for analysis purposes were based on the same types of activities and were on the same land types and soils as those proposed in the Butte Lookout Project. In all cases, field reviews documented all forms of soil impacts observable (six criteria). Field assessments followed procedures set forth by Howes (2000) and Howes (2007).

Prior to undertaking soil data collection, and under the direction of a qualified soil scientist, field crews were intensively trained in soil assessment protocols as described by Howes (2000, 2007). Further, crews spent supervised time refining their abilities to recognize various degrees of soil disturbance using visual observations and direct soil sampling procedures. For the 2006 field season, for example, that crew made over 800 individual soil observations and processed nearly 100 soil bulk density samples as baseline references for their observations before undertaking data collection for the Butte Lookout analysis.

In order to insure that all crew members were using identical criteria to classify soil sample points into one of the Howes Disturbance Classes, a calibration trial was performed at Blue Mountain Recreation Area in Missoula. During this trial, all crew members worked as a group to identify several locations that met the criteria for each of the Howes (2000) Disturbance Classes ranging from zero (no disturbance) to 5 (severe disturbance). Disturbance Class 5 was not identified at the calibration trial area or at any other location during the course of data collection. Howes (2007) differs from Howes (2000) by compressing six soil disturbance classes into four soil disturbance classes.

At each location, crew members dug soil pits, discussed findings, and collected soil cores. Soil core samples were used to calculate the mean bulk density for each of the sampled Howes Classes. The average bulk density values were used as a calibration tool to insure that visual qualifiers of disturbance were indicative of changes in soil quality. By working together as a group to identify soils in each of the categories, crew members were able to standardize their interpretations and assure uniformity and

consistency. A detailed account of the field crew preparation is contained in the document, “Lolo NF Soil Characterization Assessments: 2006 Pre-season Field Crew Training, Calibration and Standardization”.

Before assessing potentially disturbed soil conditions in proposed activity areas, crews made “calibration” visits to the individual soil map units to establish a baseline undisturbed condition for that soil type. The field sampling strategy was to first survey smaller proposed units of representative land types at an intensity calculated to provide a high degree of certainty that a 15 percent areal detrimental disturbance in that unit would be detected. A sampling intensity of 6 points per acre would provide 90 percent confidence that such an areal extent of detrimental disturbance would be detected (Page-Dumroese et. al, 2006). After completing several hundred direct soil observations at that intensity, a number of proposed units were found to have an overall assessment of “no detrimental disturbance”. This low incidence of residual impact allowed the crew to conclude that there was limited variability in disturbance levels on similar land types with similarly aged previous treatments. Sampling intensity was adjusted for larger units based on the variability of the data as it was being collected. Sampling intensity within each unit provided no less than an 80 percent confidence level of detecting 15 percent detrimental disturbance within the area of the unit.

Existing Conditions

Project Area Land Systems Inventory (LSI) Designation

The Lolo National Forest Land Systems Inventory (LSI) is a correlated Order 3-4 soil survey published in 1985 and based on extensive field investigation and detailed laboratory analyses. Land Systems Inventory mapping units segregate areas of land based on a set of given landforms, geologic materials and vegetation that are used to classify the areas for descriptive and interpretative purposes. Although there are over 100 unique LSI mapping units for the Lolo NF, mapping units describe the most prevalent conditions thus not every acre within a mapping unit corresponds exactly to the mapping unit description.

The LSI mapping units are the basis for the soils analysis of the Butte Lookout analysis area. The LSI provides numerous tables of soil interpretations including “sensitivities” and “limitations”. Land Systems Inventory mapping units found in the project area that have higher sensitivities to disturbance are displayed in groupings that are similar both in description and interpretation in Table 58. These interpretations are informative and suggestive of potential soil responses to management activities and are “tools” to aid in developing appropriate treatments and management requirements. For example, there are seven tractor units on land types identified in Table 58: Units 9A, 17A, 22, 26, 27, 34 and 43. Without careful unit layout, season of operation specification, and close supervision, these units could potentially be subject to detrimental soil disturbance. With appropriate attention however, the Land Systems Inventory notes that in the land types listed in Table 58, “Slopes less than 35 percent are well-suited for tractor harvest.”

Table 58 Land Types of the Butte Lookout Project Area with Identified Sensitivity to Disturbance (Soil Descriptions and Proposed Activity Units)

Land Types (LSI Map Units)	Description	Acres of Proposed Treatment	Interpretation	Treatment Unit Numbers
30SA	Moderate relief mountain slopes of 30% to 55% gradient with soils derived from mica-shist sub-stratum with volcanic ash loess surface layers.	204	Highly erodible and compactible. Low bearing strength; ruts easily. Road cuts slough or slump easily.	2,3,4,5,6,7,9,9A, 10,11,12,13,17A, 19,20,21,22,26, 37,38,39,41,42,43
30SB	Similar physical makeup as 30SA only cooler and wetter	236	Similar response as 30SA though more probable because of being wetter.	15,16,22,23,24,25, 27,27A,28,29,31, 33,34,35,36
30KB	Moderate relief mountain slopes of 30% to 55% gradient with soils derived from well-weathered granitic sub-stratum with volcanic ash loess surface layers.	11	These are coarse textured soils that erode and ravel easily. Their coarseness limits water availability and they may be difficult to revegetate.	33
32KA	Broad convex ridges with slopes less than 35% and soils derived from well- weathered granitic sub-stratum with volcanic ash loess surface layers.	24	This is a similar coarse textured soil to 30KB but occurs on more gentle slopes thus is less prone to raveling and erosion. Sediment delivery efficiency is low.	34,35
43SA	This landtype is a high-elevation, gently concave basin in mica-shist with a thin surface layer of volcanic ash loess.	9	Springs and seeps are frequently encountered. Water tables are seasonally high and potential for slumps is high.	22,26
64SB	Steep mountain slopes generally greater than 55% slope with soils derived from mica-shist sub-stratum with volcanic ash loess surface layers	30	Highly erodible and compactible. Low bearing strength; ruts easily. Road cuts slough or slump easily. Slope steepness increases sediment delivery efficiency.	13,14,37,38,40,41

Past Disturbances and Existing Soil Condition

Natural disturbances include glaciation, floods, mass failures, drought, plant diseases and insect infestations, and wildland fires. Such natural processes acting over time have shaped the soils, landscapes, and vegetative cover of the Butte Lookout analysis area. Natural disturbances are generally not considered to create detrimental soil disturbances although Regional Soil Quality standards define severely burned soil to be detrimentally disturbed while the effects are present. There are no detrimental conditions as a result of fire, either wildfire or prescribed fire, present in the project area.

Human disturbances on National Forest System lands within the project area include road construction, timber harvest, prescribed fire, fire suppression, and developed and dispersed recreation. These activities are the basis for the discussion of current conditions and effects of implementing the proposed activities.

Existing Disturbance Effect on Soil Quality and Land Productivity

Soil Erosion. Soil erosion in the project area is concentrated on roads. Road erosion has direct effects on water quality, but because it is not a component of soil quality assessment it is evaluated in the Hydrology and Fisheries section of this document. The most recent ground-based harvesting was completed in the mid-1990s. Surface vegetation has returned to disturbed sites either through seeding or natural recovery, and skid trails and landings in the project area have all had erosion control features completed, which reduces or eliminates soil erosion.

Soil Productivity. Forest ("land") productivity is "the summation of the productivities of the individual landscape elements (stands) that comprise the forest and is the integration of soil productivity, species composition and stocking, and stand history (Grigal 2000)". If soil productivity is adversely affected due to compaction, this will have an impact on the overall productivity of the forest. Forest productivity is difficult to measure, so oftentimes, soil quality is used to estimate the potential productivity (Little et al., unknown year). Other factors, such as litter accumulation (Harmand et al. 2004), above ground biomass (Harmand et al. 2004), and tree growth may also be used to estimate forest productivity.

The Lolo NF has explored the connection between forest management activities and soil productivity changes. Several dozen scientific studies were carefully researched (citations and a literature summary, "Past Harvest Compaction and the Potential Impacts on Forest Productivity", are included in the Project File). Broadly, the studies reveal that soil compaction is the logging-related disturbance most likely to affect productivity; that soil compaction results from the heavy ground-based equipment used to cut, fell and process the trees; and that the impacts of compaction on productivity vary by tree species, soil type, and plant stress as related to climate regime.

The objectives of the Regional Soil Quality Standards include managing NF lands "without permanent impairment of land productivity and to maintain or improve soil quality". This is a requirement of the *National Forest Management Act* of 1976. Robert F. Powers, a research Soil Scientist for the Forest Service, notes that while "net primary productivity" is the fundamental indicator of a forest's well being, it is extremely difficult to measure (Powers, 2002).

This author further states:

> "Monitoring soil and site processes is not feasible at an operational scale. Therefore, USDA Forest Service monitoring strategy centers on measurable soil variables, which, if altered beyond a threshold, indicate that potential productivity has been degraded. These thresholds of soil quality are based partly on research, but largely on professional judgment."

In 1998, Powers et al. described the Forest Service monitoring strategy as focusing on measurable soil disturbance variables such as compaction, ground cover, soil displacement and organic matter abundance that influence important site processes.

This is the suggested focus because, “Monitoring soil and site processes is not operationally feasible.” So it is through discussion of the soil quality standards that soil productivity is disclosed.

This strategy further provides that each Forest Service region develop “standards” for each variable that mark thresholds for detrimental soil disturbance.

> “A threshold for detrimental disturbance is defined as a change in any monitoring variable sufficient to trigger a 15 percent decline in soil productivity from that of the predisturbed condition, a value judged to be the smallest change detectable statistically at operational levels of monitoring. This does not imply that absolute productivity has declined 15 percent, but merely that a detrimental disturbance threshold has been passed.” (Powers, et al, 1998)

Both in Powers, et al (1998) and Powers (2002) there is the acknowledgement that these soil quality thresholds are based partly on research but largely on professional judgment; the professional judgment though of senior research and academic soil scientists. This threshold approach is accepted in the scientific literature and cited in such examples as:

Block R,Van Rees KCJ, Pennock DJ. 2002. Quantifying harvesting impacts using soil compaction and disturbance regimes at a landscape scale. *Soil Science Society of America Journal* 66:1669-1676

Geist, J.M.; Hazard, J.W.; and Seidel, K.W. 1989. Assessing physical conditions of some Pacific Northwest volcanic ash soils after forest harvest. *Soil Science Society of America Journal* 53: 946-950.

Moffat AJ. 2003. Indicators of soil quality for UK forestry. *Forestry* 76(5): 547-568.

Rab MA. 1999. Measures and operating standards for assessing Montreal process soil sustainability indicators with reference to Victorian Central highlands forest, southeastern Australia. *Forest Ecology and Management* 117: 53-73.

Rab, M.A. 2004. Recovery of soil physical properties from compaction and soil profile disturbance caused by logging of native forest in Victorian Central Highlands, Australia. *Forest Ecology and Mgt*. 191 329-340.

As just stated, forest productivity is both difficult to measure and a function of a number of variables besides soil quality.

The NFMA requirement that, “management systems not produce substantial and permanent impairment of the productivity of the land;” is broad direction of how the nations public and private forests are to serve the national interest (U.S.C. 1602(3)).

“…in recognition of the vital importance of America’s renewable resources of forest, range and other associated lands to the Nation’s social and economic well-being, (U.S.C. 1603(a))”

The Forest Service and other Federal agencies are to:

> “evaluate opportunities for improving their yield of tangible and intangible goods and services (U.S.C. 1603(a)(2)), and “make a determination of the present and potential productivity of the land, and of such other facts as may be necessary and useful in the determination of ways and means needed to balance the

> demand for and supply of these renewable resources, benefits and uses in meeting the needs of the people of the United States (U.S.C. 1603(a)(6)(b)).”

The “management systems” considered for this project are a response to the above NFMA direction to maintain long-term productivity and improve the yield of tangible and intangible goods and services while maintaining a way to balance supply and demand of renewable forest resources.

In addition to the requirement to maintain productivity of the land, NFMA also instructs the Forest Service to: “Insure that timber will be harvested from National Forest System lands only where – (i) soil, slope or other watershed conditions will not be irreversibly damaged.”

Monitoring of previously harvested timber sale units on the Lolo NF suggested that in units 35 to 45 years old, detrimental soil disturbance appeared to have dissipated. To test this “hypothesis”, all of the soil monitoring data collected from across the Lolo NF during 2005 and 2006 was pooled and reviewed. Multi-point transect data was available from nearly 200 individual units (proposed activity areas). These 200 units were screened to identify those units where the entire unit had received ground-based harvesting in a specific time period with out any complicating “intermediate” treatments. There were only 18 units that fit these criteria. These 18 units encompass 445 acres and a total of 1,691 individual observations of soil quality.

The units were stratified by 10-year age categories (less than 10 years old, 11 – 20 years old, etc). The observed residual detrimental disturbance declined with increasing elapsed time from the past harvest for the first three decades and then increased again after 40 years of elapsed time. In that era, ground disturbance during harvest was an intentional objective for the purpose of promoting a mineral soil seed bed for “natural regeneration.” More tree seeds in contact with bare soil germinated and established themselves than where duff and litter were present. While silvicultural prescriptions continue to specify “site preparation” to achieve mineral soil for natural regeneration, the amount now considered necessary is much less.

The data available from the 18 units evaluated show that percent detrimental disturbance from a mechanical harvest prescription applied to an activity area declined over time from 9 percent the first decade, to 4 percent the second decade, 2 percent the third decade, no data from the fourth decade, and back up to 4 percent again after 40 years. This relationship is illustrated Figure 5 below.

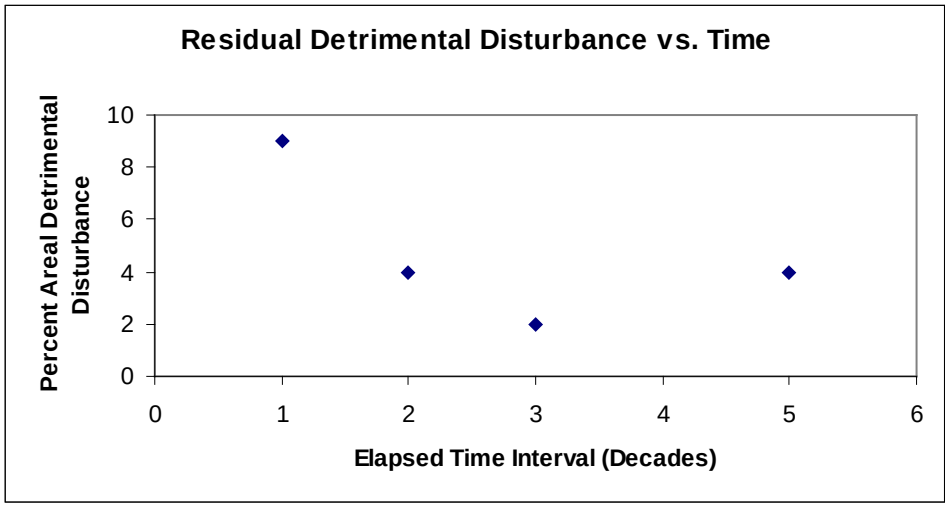

Figure 5 Dissipation of Harvest Induced Detrimental Disturbance with Time

Data from the other monitored units followed the same pattern; older past harvest units exhibit less residual detrimental disturbance than harvest units less than 10 years old. These units did not meet the strict selection criteria of a single uniquely identified prescription in the decadal intervals established.

To further explore this relationship between age of disturbance and the amount of residual detrimental disturbance, a follow-up monitoring project was designed for the field season of 2007. In this project, previously harvested units were screened to identify those in specific age categories where only one unique ground-based activity occurred over the entire unit. Over the course of the field season, 142 units harvested between 1979 and 2005 were monitored. These units were not among those monitored in 2005 and 2006. Results of this new monitoring are documented in the report, “Soil Disturbance Recovery: Relating Current Levels of Detrimental Disturbance to Past Ground-based Harvest Operations.”

The additional monitoring confirmed that where a unique ground-based treatment was applied throughout a unit, less residual detrimental disturbance was detected with increasing time since the occurrence of that treatment. The detrimental soil disturbance currently detectable in monitored units versus its age is displayed in Figure 6. While there is a wide variation in the data, a couple of observations are important in our consideration of soil quality standards. First, of the 142 units monitored only 8 exceed the 15 percent threshold established for evaluating whether the unit meets Regional Soil Quality Standards. Second, no unit harvested prior to 1990 exceeds the 15 percent threshold.

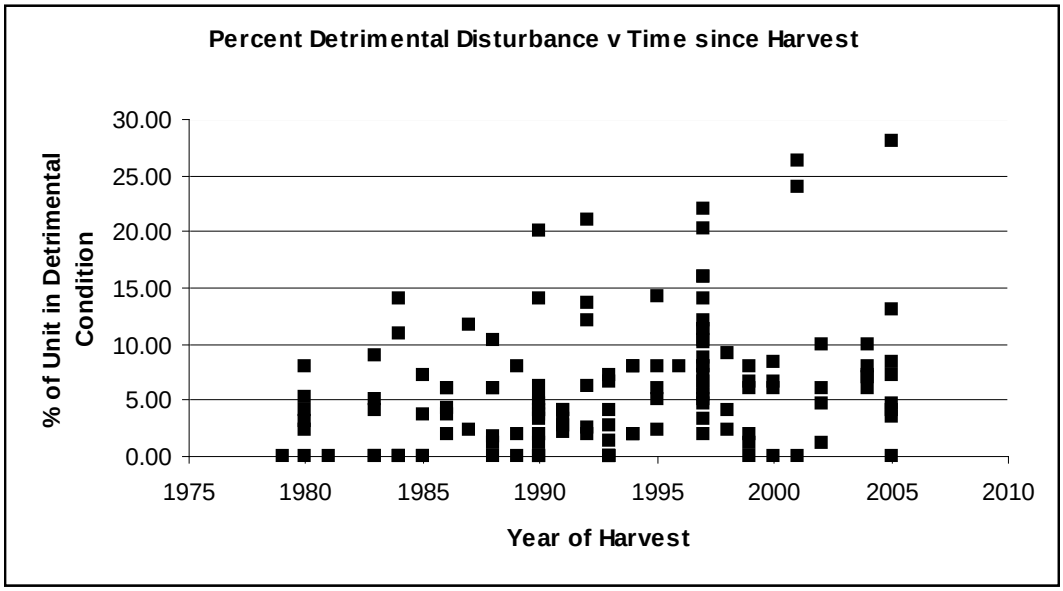

Figure 6 2007 Monitoring of Detrimental Soil Disturbance by Ground-Based

When the data are grouped in five-year intervals and averaged, more observations become evident, see Figure 7. The average detrimental disturbance of units in all age groupings is less than the 15 percent soil quality standard threshold. And, the largest visible dissipation of detrimental disturbance appears to be between 10 and 15 years after treatment.

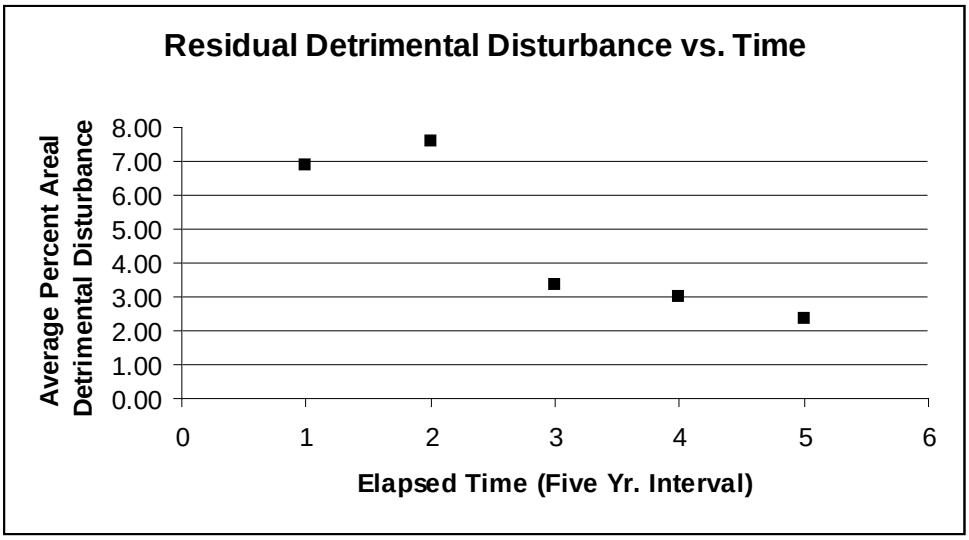

Figure 7 Dissipation of Harvest Induced Detrimental Disturbance with Time (2007 Data)

The data presented here demonstrate that initial detrimental disturbance resulting from ground-based timber harvesting diminishes over time without active reclamation and, initial detrimental disturbance does not irreversibly damage activity area soils.

Past Management in Proposed Activity Areas

Alternatives 4 and 5 include one fairly large unit (unit 67) of noncommercial treatment, an Ecosystem Maintenance Burn (EMB). During Interdisciplinary Team discussions, four additional EMB treatments were developed and incorporated into Alternative 5. The three added EMBs are units 44, 45, 47. None of the noncommercial treatment units have had any previous activity and thus have no existing soil quality impacts (see Table 59 below).

Table 59 Activity History and Residual Detrimental Soil Conditions in Proposed Nonharvest Treatment Units of Alternatives 4 and 5

Unit No.	Alternative	Area (acres)	Previous Activity? (Y/N)	Proposed Treatment[1]	Existing Percent Detrimental Disturbance
44	5	29	N	EMB	0
45	5	7	N	EMB	0
47	5	21	N	EMB	0
67	4 and 5	109	N	EMB	0

[1]EMB is Ecosystem Maintenance Burn.

Alternative 4 includes 67 units where some amount of commercial timber harvest is proposed. As the Interdisciplinary Team reviewed and considered these activities they developed Alternative 5, where recommended treatments were deferred or modified for 9 of the 67 proposed units. These 9 units, along with all other units proposed in Alternative 4, were field checked to determine whether or not previous activity had occurred to enable a further determination of existing soil quality. There has been no previous activity in any of the 9 units thus no detrimental soil disturbance exists (see Table 60).

Table 60 Activity History and Residual Detrimental Soil Conditions in Units where Proposed Treatments Differ from Alternative 4 to Alternative 5

Unit No.	Area (acres)	Proposed Alternative 4 Treatment	Proposed Alternative 5 Treatment	Previous Activity? (Y/N)	Existing % Detrimental Disturbance
44	29	S/L WTY/UB	EMB	N	0
45	7	S/L WTY/UB	EMB	N	0
47	21	T WTY	EMB	N	0
61	7	T WTY	Dropped	N	0
62	15	S/L WTY	Dropped	N	0
64	118	H UB	H UB3	N	0
66	60	T WTY/UB	H UB3	N	0
66A	57	S/L WTY/UB	H UB	N	0
66C	67	H UB	H UB3	N	0

S/L is “skyline”; WTY is “whole tree yarded”; UB is “underburning”; T is “tractor” ; H is “helicopter”
EMB is “ecosystem maintenance burning.” units 61 and 62 are dropped from Alternative 5.
In Alternative 5, portions of a unit that timber sale purchaser can not helicopter yard may be EMB only.

Tables 61-63 display all units proposed for commercial harvest segregated by the means used to remove the timber from the units (tractor, skyline or helicopter). The tables show, by unit, whether any previous activity has occurred in that unit and, if so, whether any residual detrimental disturbance was detected by on-the-ground multi-point transects.

Table 61 Activity History and Residual Detrimental Soil Conditions in Proposed Tractor Harvest Units Common to Alternatives 4 and 5

Unit No.	Area (acres)	Previous Activity? (Y/N)	Existing % Detrimental Disturbance	Proposed Post Harvest Treatment[1]
9A	3	N	0	None
17A	13	N	0	UB
22	32	N	0	None
23	9	N	0	UB
27	24	Y	10	Road Oblit.[2]
34	56	N	0	UB
43	6	Y	1	None
51A	10	N	0	None
53	15	N	0	None

[1]All Tractor harvest units would be "whole tree yarded". UB is "underburning".
[2]Nonsystem historic road (HIR) about one mile long

Table 62 Activity History and Residual Detrimental Soil Conditions in Proposed Skyline Harvest Units Common to Alternatives 4 and 5

Unit No.	Area (acres)	Previous Activity? (Y/N)	Existing % Detrimental Disturbance	Proposed Post Harvest Treatment
2	19	N	0	None
4	6	N	0	None
6	11	Y	0	None
7	17	N	0	None
9	22	N	0	None
10	3	N	0	None
11	4	N	0	None
12	2	Y	0	None
13	5	Y	7	None
15	8	Y	8	None
17	29	N	0	UB
19	10	N	0	None
21	10	N	0	None
24	20	N	0	UB
25	15	N	0	UB
26	13	N	0	None
27A	12	Y	10	Road Oblit.[1]
29	17	N	0	UB
31	29	N	0	UB
33	43	N	0	UB
36	8	Y	11	None
37	8	Y	0	None
38	25	Y	0	None
39	22	Y	0	None
40	6	Y	0	None
41	16	Y	3	None
42	10	Y	0	None
48	5	N	0	None

Unit No.	Area (acres)	Previous Activity? (Y/N)	Existing % Detrimental Disturbance	Proposed Post Harvest Treatment
49	8	N	0	None
50	11	N	0	None
51	33	N	0	None
55	6	N	0	None
57	6	N	0	None
58	7	N	0	None
69	24	N	0	None
70	26	N	0	None
71	3	N	0	None

[1]Non-system "HIR" road about one mile long

Table 63 Activity History and Residual Detrimental Soil Conditions in Proposed Helicopter Harvest Units Common to Alternatives 4 and 5

Unit No.	Area (acres)	Previous Activity? (Y/N)	Existing % Detrimental Disturbance	Proposed Post Harvest Treatment
3	4	N	0	LOP[1]
5	33	N	0	LOP
14	2	Y	0	LOP
16	6	N	0	LOP
20	11	N	0	LOP
28	18	N	0	UB
35	47	N	0	LOP
52	17	N	0	LOP
56	11	N	0	LOP
59	19	N	0	LOP
64[2]	118	N	0	UB
65	79	N	0	UB
66B	38	N	0	UB
66C[2]	67	N	0	UB

[1] "LOP" means limbs, tree tops and other small woody debris are cut into small pieces and scattered through the unit. "

[2] In Alternative 5 it is likely that the timber sale purchaser may not be able to yard portions of these units; these units would then be EMB only.

During data collection, the soil disturbance detected from previous activities appeared to be from jammer roads, log skidding and logging slash piling. Compaction, displacement and removal of surface organic matter (duff) are impacts possible with the use of ground-based harvest systems. The degree of soil disturbance depends heavily on: soil characteristics such as texture; harvest system employed; and logging system operator efficacy (Grigal 2000, Powers et al 2005). The tables above display, by unit, the degree of detrimental disturbance encountered during multi-point transects in all previously harvested activity areas in the Butte Lookout analysis area. Detrimental disturbance conditions are defined by prescribed levels of compaction, rutting, displacement, severely burned soil, surface erosion, and soil mass movement. No erosion, mass movement, severe burning or rutting impacts were observed in the proposed units.

As seen in the tables above, all proposed activity areas (units) in the Butte Lookout analysis area currently meet the Regional Soil Quality Standards.

Environmental Consequences

Alternative 1 (No Action)

Direct and Indirect Effects

Soil Erosion. Soil erosion rates would fluctuate with natural changes in vegetation. In some cases, natural disturbance such as fire could cause a short-term increase in soil erosion. Alternative 1 would allow any current soil erosion to slowly decrease as natural revegetation returns to soils that lack plant cover.

Soil Productivity. Alternative 1 would not cause short-term effects on the soil resource over and above the existing condition. No additional timber harvest, stand treatment, road work, reclamation or prescribed burning would alter the existing soil condition.

Organic Matter. With implementation of Alternative 1, all standing dead trees would eventually fall over and contribute coarse woody debris. Needles and branches would remain on the site and fall to the ground. 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 a fire or a windstorm opens the tree canopy and alters the recycling process again.

Microorganisms. 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 natural events such as fire, insects, and disease cause changes.

Physical Soil Disturbances. Alternative 1 would cause no additional soil compaction, rutting, puddling, or soil displacement. Soil productivity in areas where past timber management compacted soils would slowly improve as plant roots, soil organisms, and freeze-thaw events loosen the soil. The most severely compacted soil would recover within 70 years without additional disturbance (Gonsior 1983). Sites that are less severely compacted would recover more rapidly. Data collected within the last three years on the Lolo National Forest suggests that detrimental disturbance dissipates rapidly after the first decade; see Tables 58 and 59 and accompanying discussion.

Mass Failures. Interpretations of the characteristics and behaviors of the soils and landforms in the project area contained in the Lolo Land Systems Inventory do not identify mass failure as a particular risk. Alternative 1 would not affect the risk of mass failures.

Alternatives 4 and 5

Direct and Indirect Effects Common to Both Alternatives

Alternative 4 includes commercial timber harvest on 67 units (1,353 acres) and noncommercial Ecosystem Maintenance Burning (EMB) on one unit of 109 acres. During Interdisciplinary Team review another alternative, Alternative 5, was developed.

Alternative 5 consists of 62 commercial units (1,274 acres) with four Ecosystem Maintenance Burning units totaling 166 acres. In contrast to the units proposed in Alternative 4, in Alternative 5 Units 44, 45, 47 would be EMB; any portions of units 64, 66 and 66C that the timber sale purchaser couldn't helicopter yard would become EMB units instead of commercially harvested. Units 61 and 62 were dropped (see Table 64). The remaining units are treated identically in Alternatives 4 and 5 (except for units 66 and 66A – see Table 58). There are no differences between Alternative 4 and Alternative 5 in terms of post-harvest slash treatment. For the most part, fallen trees will be transported to landing areas without "topping or limbing"; they will be "whole tree yarded." Processing will take place at landings before logs are loaded onto trucks for transport to the mill. These activities would have no additional effect in terms of detrimental soil disturbance.

Table 64 Unit Logging Systems Planned for Alternatives 4 and 5

Alternative	Total Number of Units	Number of Commercial Harvest Units	Number of Noncommercial Units	Number of Tractor Units	Number of Skyline Units	Number of Helicopter Units
4	68	67	1	12	41	14
5	66	62	4	9	37	16

Noncommercial Vegetation Treatments

Alternative 4 includes 109 acres of ecosystem management prescribed underburning (ecoburns) of brush, forest understory, and other forest vegetation. Alternative 5 includes 166 acres of the same treatment. The effect of this treatment would be similar to that of a low severity wildland fire that reduces fuels while leaving live trees, shrubs, and other forest vegetation behind. Burning in spring would reduce effects caused by high soil heating such as loss of nutrients through volatilization (DeBano 1979 in DeBano, et al. 1999). Soil organisms necessary to recycle nutrients would be available on the burned sites. Organisms would move into the areas under burn piles when soil conditions are recovered enough to provide habitat for the organisms. The ecoburning treatments proposed for these units would not involve any form of ground-based equipment. The only alteration of the forest floor that might occur would arise from underburning the smaller trees and limbs and branches that have fallen off the trees. This burning is, of necessity, carried out in early spring and late fall when moisture contents of the fuel and soil are high so as to prevent the planned use of fire from getting out of control. The higher moisture in the fuel and soil prevents temperatures at the soil surface from becoming high enough to cause "severe soil burning" a detrimental disturbance of the soil. These low-intensity controlled burns are designed to have no measurable detrimental impacts to the soil. See Table 65 for the existing and potential post-project levels of detrimental soil disturbance by unit.

Table 65 Calculated Potential Detrimental Soil Conditions in Proposed Noncommercial Treatment Units

Unit No.	Existing % Detrimental Disturbance	Potential Increase in Detrimental Soil Condition (%) Alternative 4[1]	Potential Post Treatment Detrimental Soil Condition (%) Alternative 4[1]	Potential Increase in Detrimental Soil Condition (%) Alternative 5	Potential Post Treatment Detrimental Soil Condition (%) Alternative 5
44	0	N/A	N/A	0	0
45	0	N/A	N/A	0	0

Unit No.	Existing % Detrimental Disturbance	Potential Increase in Detrimental Soil Condition (%) Alternative 4[1]	Potential Post Treatment Detrimental Soil Condition (%) Alternative 4[1]	Potential Increase in Detrimental Soil Condition (%) Alternative 5	Potential Post Treatment Detrimental Soil Condition (%) Alternative 5
47	0	N/A	N/A	0	0
67	0	0	0	0	0

[1]In Alternative 4, these units are proposed for commercial treatment – see Table 66

Table 66 Calculated Potential Detrimental Soil Conditions in Units where Proposed Treatments Differ from Alternative 4 to Alternative 5

Unit No.	Existing % Detrimental Disturbance	Potential Increase in Detrimental Soil Condition (%) Alternative 4	Total Potential Post-Treatment Detrimental Soil Condition (%) Alternative 4	Potential Increase in Detrimental Soil Condition (%) Alternative 5	Total Potential Post-Treatment Detrimental Soil Condition (%) Alternative 5
44	0	3	3	0	0
45	0	3	3	0	0
47	0	9	9	0	0
61	0	3	3	Not in Alt. 5	N/A
62	0	3	3	Not in Alt. 5	N/A
64[1]	0	2	2	2	2
66	0	9	9	2[1]	2[1]
66A	0	3	3	2	2
66C[1]	0	2	2	2	2

[1]Units 64, 66, and 66c are helicopter units in Alternative 5 but there are likely portions of the units that the timber purchaser will not be able to helicopter yard economically; these areas would be EMB only.

Commercial Vegetation Treatments Common to Alternatives 4 and 5

Several of the commercial units would be harvested using a combination of a track-mounted “feller-buncher” and a rubber-tired skidder. This combination is referred to as “tractor” harvesting for convenience and because it is an accepted term for ground-based logging. To reduce potential surface disturbance, those “tractor” units occurring on the more sensitive land types listed in Table 58 would be harvested in the winter over 24 inches of settled snow or on frozen ground. Skyline harvesting would be used for the majority of the units in this project, and helicopters would be used to fly the commercial timber from the remaining units. See Table 64 for logging system use by alternative.

The type of logging system used to remove timber from a harvest unit affects the amount and degree of potential soil disturbance that may occur during logging operations. Several studies (Klepac, et. al 1999, Megahan et.al, 1995 and Clayton, 1990) cite an earlier paper by Megahan (1981) noting the following relative soil disturbance figures. Helicopter logging caused the least disturbance with an average of 4 percent of an “activity area”, skyline harvesting caused 9 percent, and ground-based harvesting caused 21 percent. Kepac and Reutebach (2003) expanded the previous discussion to include the range of disturbance figures included in the averages reported. The range of values for ground-based harvest was 7 to 36 percent compared to a range of 3 to12 percent for skyline and 1 to 5 percent for helicopter harvesting. Kepac and Reutebach further note that a standardized soil disturbance rating system was not used in the nine studies that produced the original data. To them, this explained the wide ranges in reported disturbance.

Rab, et.al, (2005), citing other studies of relative logging system soil effects, compares "mineral soil exposure" generated by ground-based, skyline, and helicopter logging systems. Where individual studies reported results of multiple logging systems, helicopter logging exposed about half the area compared to skyline harvest and about 16 percent of the area compared to ground-based systems. Mineral soil exposure reflects an areal amount of disturbance but not the degree or consequence of disturbance.

A valuable discussion of how the broad term "disturbance" should be viewed relative to soil quality impacts is presented by a joint British Columbia Ministry of Forests/USDA Forest Service team of Soil Scientists (Curran, et. al, 2000). They emphasize the point that most soil scientists and foresters recognize that not all soil disturbance is detrimental. "Disturbance" may change the physical, chemical, or biological properties of the soil but no direction or consequence of these changes are specified by just the term "disturbance".

"Foresters, for example," they state, "commonly prescribe soil disturbance as site preparation for seedling planting and establishment. Disturbance related to these activities is usually not considered detrimental or counted as disturbance by various jurisdictions' soil disturbance guidelines."

Another basis is needed for deciding when a given disturbance type or severity is considered detrimental (Curran, et. al, 2000). The Regional Soil Quality Standards provide these specific definitions of severity to be considered detrimental. For example, "compaction" is considered to be detrimental when soil bulk density is increased by at least 15 percent above an undisturbed value. Additional definitions are presented in the Analysis Methods section of this report.

Soil Erosion. Undisturbed forest soils typically have very low erosion rates. Common human-caused disturbances include prescribed fire and timber harvest. Reducing the amount of bare, disturbed soils in harvested areas minimizes soil erosion. The practices that maintain soil productivity, such as leaving organic material on the soil surface and reducing the area impacted by skid trails, also reduce the risk of soil erosion. In addition, implementing specific erosion control measures such as water bars, placing slash on disturbed soils, and vegetating disturbed soils would also reduce erosion.

With the implementation of BMPs and mitigating measures (see Management Requirements in Chapter 2), the total amount of soil erosion caused by the proposed activities would be small and would decrease with time as vegetation returns to the soils.

Road improvement accomplished by implementing best management practices on existing roads would effectively reduce the amount of soil erosion from those roads by, for example, controlling surface runoff, providing buffer strips (places where water would run off the roads into vegetation where the water soaks into the soil and sediment is trapped), installing gravel-surfacing, and grass seeding unprotected road cut and fill slopes.

Soil Productivity. Both alternatives were designed to incorporate management practices and mitigating measures that would reduce the effects from timber harvest on soil resources and ensure that all activities meet the Regional Standards. Management Requirements are listed in Chapter 2. The effectiveness of properly applied BMPs is discussed in Appendix D. For units where timber harvest is accomplished using skyline

and helicopter yarding systems, post-harvest treatments for slash reduction or site preparation would be by nonmechanical means; that is slashing, underburning, planting, or natural regeneration would occur.

Organic Matter. The project is designed to leave a variety of organic matter on the site; a practice that Harvey, et al. (1994) say maintains productivity. The Lolo National Forest Down Woody Material Guide (2006) contains specific recommendations and prescriptions for coarse woody debris retention by forest habitat type and other environmental features. By meeting these retention requirements, long-term soil productivity would be maintained at levels suitable for growing forest vegetation and soil erosion would be reduced.

Jurgenson, et al. (1981) studied logging followed by low severity slash burning in northwestern Montana. The authors concluded there would be no long-term depletion of nitrogen reserves because lost nitrogen would be more than replenished by inputs from precipitation and by biological nitrogen fixation over a rotation of 100 to 150 years. Harvey and others (1994) note that careful prescribed burns or mechanical site preparation can be practiced on most sites with relatively little effect on soil organic content.

All harvest prescriptions would leave a portion of the existing stand on the site (refer to Vegetation section, Appendix A for treatment descriptions, and Project File, Vegetation section).

Microorganisms. Jurgenson, et al. (1977) note that after a fire, soil micro-flora recovers quite rapidly, frequently to levels greater than prefire levels. Borchers and Perry (1990) discussed the important role that less disturbed areas of soil play in inoculating soil that lacks or has reduced numbers of soil microorganisms. They state that unburned areas within burns, adjacent unburned areas, unburned large woody debris, and soils that have only minor amounts of disturbance, all contain propagules for fungi, bacteria and other soil organisms and that these propagules are dispersed by wind, animals, and other agents. The organic matter left on the harvest areas would benefit soil organisms by providing substrate and habitat for soil organisms to survive in. All alternatives would leave both dead and live trees in sufficient amounts (refer to Vegetation section, Appendix A for treatment descriptions, and Project File, Vegetation section).

Soil compaction, displacement, and other physical disturbances can reduce the ability of soil to exchange oxygen and carbon dioxide thus affecting the ability of soil organisms to survive. However, favorable habitat for soil organisms would be maintained because all proposed activity areas are designed to reduce soil disturbance and meet the Regional Soil Quality Standards.

Timber harvest increases the amount of sunlight and moisture available to soils. These warm, moist conditions increase microbial activity and decomposition rates, which in turn increases the amount of nutrients available in the soil. The proposed treatments within the Butte Lookout Project area would retain trees, shrubs, grasses, and forbs that would fully utilize the additional available nutrients before they could leach beyond the root zone.

Management practices discussed above that leave a variety of organic matter on the site and minimize soil compaction would leave a favorable environment for the survival of soil organisms in the Butte Lookout Project activity areas proposed for treatment. Any

reduction of productivity attributable to soil organisms would be insubstantial and short-term.

Physical Soil Properties. Commercial vegetation treatments and post-harvest remediation of proposed cutting units is designed to ensure detrimental soil impacts affect less than 15 percent of the activity area. This objective would be achieved by implementing BMPs and Management Requirements (see Chapter 2). These management practices and mitigating measures would maintain soil quality by reducing the extent of compaction, displacement, and other physical disturbances to the soil.

Tractor Yarding. Tractor systems generally create more detrimental soil disturbance than skyline or helicopter systems. Tractor yarding that is followed by either underburning or excavator piling would meet soil quality standards when all equipment operates on dedicated skid trails spaced far enough apart to disturb (detrimentally) less than 15 percent of the area, including the landings.

Ground pressure is a function of weight and contact area with the ground. Comparing the ground pressure of machines used in the timber harvest process is a way to determine if the equipment used in different units is equivalent. The ground pressure of machines typically used in this area ranges from 6 to 9 pounds per square inch. During the Lolo NF 2005 field season, intensive soil monitoring of a just completed “tractor” harvest unit was conducted (Unit 21 of the Pattee Blue Timber Sale). Data were collected at an intensity of 10 observations per acre, sufficient to provide more than 95 percent confidence that an areal detrimental disturbance of 15 percent would be detected with an accuracy of plus or minus 10 percent (Page-Dumroese, et al., 2006). The equipment used for the cutting and harvesting the trees in the monitored unit (a track-mounted “feller-buncher” and a rubber-tired skidder) is similar to the equipment that would likely be used for the Butte Lookout project; at least the equipment would have the same range of ground pressure of 6 to 9 pounds per square inch. The complete report of this monitoring was submitted to the Missoula District Ranger on November 11, 2005 (see Project File). This monitoring determined that 5 percent of Unit 21 had detrimental soil conditions.

The Regional (Northern Region) Soil Monitoring Field Crew collected data on the Lolo NF during 2005 in the Boyer Salvage and Pattee-Blue timber sales (Page-Dumroese et al. 2006). Ground-based harvesting during dry summer conditions on moderate sloped soils (Pattee-Blue Unit 13 and Boyer Salvage Unit 35) found resulting detrimental soil conditions of 4 percent and 6 percent.

Additional Forest-wide soil monitoring on the Lolo NF found ground-based harvesting carried out within the last 10 years resulted in detrimental disturbance of 7 to 9 percent (see Tables 58 and 59).

Considering both recent local monitoring information and a broad range of technical literature, a value of 9 percent is used to estimate the potential detrimental disturbance that might result from ground-based harvesting during implementation of the Butte Lookout Project.

Recent monitoring of ground-based winter harvesting indicates that frozen soil or 24 inches of snow that has been compacted is effective in reducing the amount of detrimental soil disturbance. Ten timber sales on the Lolo and Flathead National Forests harvested between 1999 and 2003 prescribed this management requirement. A total of

41 units within these 10 sales were monitored, and the average detrimental disturbance of the 41 units was 4 percent (see Table 67). The monitoring notes revealed that in some cases the prescribed snow or frozen soil conditions were not in place during harvesting resulting in substantially higher impacts. The value of 4 percent will be used to reflect the effect of winter harvesting.

Table 67 Detrimental Soil Disturbance Observed in Units where Ground-Based Harvesting was Completed during Winter

Timber Sale	Number Of Units	Unit Detrimental Disturbance Range of Values (%)	Average % Detrimental Disturbance
A	6	0 – 1	1
B	2	6 – 7	6
C	1	12	12
D	2	1 - 1	1
E	12	0 - 20	4
F	3	7 - 17	12
G	4	0 – 8	3
H	3	2 – 3	2
I	3	2 – 9	5
J	5	2 - 5	2

Skyline Yarding. McIver and Starr (2000) reviewed the literature on the amount of soil disturbance from various yarding systems. They found skyline yarding disturbed about 3 percent of the soil in a unit. During the field season of 2006, 6 recently completed skyline units on the Lolo NF were monitored. Detrimental soil disturbance from skyline harvesting ranged from 0 to 8 percent and averaged 2 percent. Comparing the range and average detrimental disturbance of tractor and skyline harvesting on the Lolo NF to disturbance figures cited earlier by Kepac and Reutebach (2003), the recent Lolo NF data is at or below the low range cited. The data are also compatible with the McIver and Starr (2000) data so a value of 3 percent will be used to estimate the potential detrimental disturbance that might result from skyline harvesting during implementation of the Butte Lookout Project.

Helicopter Yarding. No harvest units where helicopters have been used to remove timber have been monitored for soil quality effects on the Lolo NF. As stated above, detrimental soil disturbance from skyline harvesting ranged from 0 to 8 percent and averaged 2 percent in recent monitoring. Comparing the range and average detrimental disturbance of tractor and skyline harvesting on the Lolo NF to disturbance figures cited earlier by Kepac and Reutebach (2003), the recent Lolo NF data is at or below the low range cited. The Kepac and Reutebach (2003) figures for helicopter disturbance are a range of 1 to 5 percent with an average of 4 percent. Relating the Lolo NF averages and ranges to the cited figures, a reasonable estimate of detrimental disturbance for helicopter harvesting for the considered alternatives is 2 percent. This value is used in Table 72 as the potential detrimental soil disturbance for helicopter harvesting in the considered alternatives.

When a helicopter is used to remove logs from a unit it “flies” them to a landing on flat ground where they can be loaded onto logging trucks. There are 9 potential landing sites that could be used to receive logs from the helicopter units being considered. Each landing would be about one acre in size and because of the concentration of activity, would likely be detrimentally disturbed throughout. Landings are likely to serve more

than one unit but at this stage of planning an individual landing cannot be definitively linked to any one or combination of units. Which landings might be used to receive logs from an individual unit is an operational decision made by the timber sale purchaser.

Potential helicopter landing sites are displayed on maps of the Alternatives 4 and 5. Considering the proximity of potential landings to proposed helicopter units, a realistic scenario of unit/landing combinations is displayed in Table 68, below. Table 68 also displays the amount of detrimental disturbance (as a percentage of area) that a landing would contribute to the units each serves. This percentage is a conservative estimate of the potential detrimental disturbance because the mix of available site selections includes “double-counting” to cover the range of possibilities.

Table 68 Helicopter Landings Associated with Helicopter Units

Harvest Unit(s)	Unit Area (acres)	Helicopter Landing Location	Landing Area (acres)	Landing Area as % of Unit Area
64 65	118 79	Extension of Rd. 17165, N. side of Unit 64 in center of section 5. Used for Alt. 4 only	1	1
66 66A 66B 66C	60 57 38 67	Extension of Rd 16726, S. side of Unit 66 complex in W. half of Section 8. Used for Alt. 4 only.	1	<1
66A 66B	57 38	Along Rd. 2175 at Unit. 70, SE Section 8. Used for Alts. 4 and 5	1	1
64 66A 66B 59	118 57 38 19	Along Rd. 2175 at Section Line 8/9. Used for Alts. 4 and 5	1	<1
52 56 59	17 11 19	Along Rd. 17144 at Units 50, 51, 51A, 52; Section Line 4/9. Used for Alts. 4 and 5.	1	2
52 56 59	17 11 19	Along Rd. 17144 at Units 51 and 53. E. half Section 4. Accessed by Temporary road. Used for Alts. 4 and 5	1.1[1]	2
3 20 5	4 11 33	Along Rd.17171 between Units 2 and 3; center of Section 3. Used for Alts. 4 and 5	1	2
3 20 5	4 11 33	Along Rd. 17171 near Unit 11; Center of Sec. 2. Used for Alts. 4 and 5.	1	2
35	47	End of Rd. 16088 at Unit 35. W. half Section 15. Used for Alts. 4 and 5	1	2
28	N/A	Landing within road prism	N/A	N/A
14	N/A	Landing within road prism	N/A	N/A
16	N/A	Landing within road prism	N/A	N/A

[1]Area includes temporary road needed to access landing.

The action alternatives would also include the construction of about half a mile of temporary road (in short segments) for access to four skyline units and three helicopter landings. The temporary road segments currently identified are identified in 69. Although

temporary roads are in place no more than one logging season, temporary roads cause a short-term loss of soil productivity lasting several decades. Recontouring, planting grasses, and spreading slash and woody material on the surface begin the process of restoring soil productivity. Restoration treatments would occur immediately after the units accessed were harvested. The calculated amount of detrimental soil disturbance contributed to the units accessed by temporary roads is displayed in Table 69.

Table 69 Short-Term Detrimental Soil Disturbance added by Temporary Roads

Unit Accessed	Length (feet)	Area (acres)	Unit Area (acres)	Existing % Detrimental Disturbance	% Detrimental Disturbance Added
Unit 2	300	0.1	19	0	0.5
Unit 2 and nearby helicopter landing	400	0.13	19	0	0.7
Unit 50 and nearby helicopter landing	300	0.1	11	0	1
Unit 58	300	0.1	7	0	1.5
Unit 70 and nearby helicopter landing	300	0.1	26	0	<0.5

Calculated effects of implementation of Alternatives 4 and 5 are displayed in the following tables. As seen in Tables 70 and 71, tractor unit 27 and skyline unit 36 have calculated levels of detrimental disturbance after harvest of 14 percent; just under the Regional threshold of 15 percent. Unit 27 contains about one mile of an “historic” roadbed that is contributing to the detrimental compaction and displacement within the unit. In this case historic means the road was built before such information was tracked in modern databases. The width and slope position of the road within unit 27 equate to an area of about two acres. During the course of harvesting the unit, the compaction within the roadbed would be broken up by ripping followed by scattering green slash and larger pieces of wood. Covering the ripped roadbed with organic material would help hold moisture in the soil, retard the tendency of the surface soil to resettle in compacted clumps, and add nutrients and organics to aid the soil recovery process. The exact amount of rehabilitation this would immediately contribute to unit 27 is not really calculable. The area of the road (2 acres) is about 8 percent of the unit area. Some recent data collection on the Lolo National Forest found that in the short-term, ripping for decompaction and adding slash improved soil condition to within about 30 percent of an undisturbed state. The road rehabilitation in unit 27 would be sufficient to assure the final condition of the unit would be within the 15 percent regional standard.

Unit 36 contains portions of two old jammer roads totaling about 1/3 mile. The width and slope position of these road lengths within unit 36 equates to an area of about ½ acre. The full length of these two jammer roads would be obliterated. Because unit 36 is planned to be skylined from a system road at the top of the unit with no mechanical equipment on the ground in the unit, the two jammer roads would be obliterated as part of the project’s substantial road decommissioning effort. The treatment of the jammer roads would be the same as described for unit 27. The reclamation within unit 36 would be about 6 percent of the unit area, and as in unit 27, would also be sufficient to maintain the unit within the 15 percent regional standard.

Table 70 Calculated Effects of Proposed Tractor Units Common to Alternatives 4 and 5

Unit No.	Existing Soil Detrimental Condition (%)	Potential Increase in Soil Detrimental Condition [1] From Harvest Activity (%)	Temporary Road Increase in Detrimental Condition [2] (%)	Total Potential Soil Detrimental Condition (%)
9A	0	4	None	4
17A	0	4	None	4
23	0	4	None	4
27	10	4	Road Oblit. No New[3]	14[4]
28	0	4	0	4
34	0	4	None	4
43	1	4	None	5
51A	0	9	None	9
53	0	9	None	9

[1]4 percent for winter harvest; 9 percent for dry season harvest; see Table 67 and discussion.
[2]Without Mitigation
[3]About one mile of existing non-system HIR road; equivalent to two acres of rehabilitation within unit
[4]Does not include rehabilitation of HIR road

Table 71 Calculated Effects of Proposed Skyline Units Common to Alternatives 4 and 5

Unit No.	Existing Soil Detrimental Condition (%)	Potential Increase in Soil Detrimental Condition From Harvest Activity (%)	Temporary Road Increase in Detrimental Condition[1] (%)	Total Potential Soil Detrimental Condition[1, 2] (%)
2	0	3	1.2	5
4	0	3	None	3
5	0	3	1	4
6	0	3	None	3
7	0	3	None	3
9	0	3	None	3
10	0	3	None	3
11	0	3	None	3
12	0	3	None	3
13	7	3	None	10
15	8	3	None	11
17	0	3	None	3
19	0	3	None	3
21	0	3	None	3
22	0	3	None	3
24	0	3	None	3
25	0	3	None	3
26	0	3	None	3
27A	10	3	Road Oblit. No New[3]	13[4]
29	0	3	None	3
31	0	3	None	3
33	0	3	None	3
36	11	3	Road Oblit. No New[5]	14[4]
37	0	3	None	3
38	0	3	None	3
39	0	3	None	3
40	0	3	None	3
41	3	3	None	6
42	0	3	None	3

Unit No.	Existing Soil Detrimental Condition (%)	Potential Increase in Soil Detrimental Condition From Harvest Activity (%)	Temporary Road Increase in Detrimental Condition[1] (%)	Total Potential Soil Detrimental Condition[1, 2] (%)
48	0	3	None	3
49	0	3	None	3
50	0	3	1	4
51	0	3	None	3
55	0	3	None	3
57	0	3	None	3
58	0	3	1.5	5
69	0	3	None	3
70	0	3	<0.5	4
71	0	3	None	3

[1]Without Mitigation
[2]Rounded to next higher whole number
[3]About one mile of existing non-system HIR road; equivalent to two acres of rehabilitation within unit
[4]Does not include rehabilitation of HIR road
[5]About one-third mile of non-system jammer road; equivalent to 0.5 acres of rehabilitation within unit

Table 72 Calculated Effects of Proposed Helicopter Units Common to Alternatives 4 and 5

Unit No.	Existing Soil Detrimental Condition (%)	Potential Increase in Soil Detrimental Condition From Harvest Activity (%)	Helicopter Landing Increase in Detrimental Condition[1] (%)	Total Potential Soil Detrimental Condition[2, 3] (%)
3	0	2	2	4
14	0	2	None	2
16	0	2	None	2
20	0	2	2	4
35	0	2	2	4
52	0	2	1[1]	3
56	0	2	1[1]	3
59	0	2	1[1]	3
64	0	2	1	3
65	0	2	1	3
66	0	2	<0.5[1]	3[4]
66B	0	2	1	3
66C	0	2	<0.5[1]	3

[1]Includes area of temporary access road
[2]Without Mitigation
[3]Rounded to next higher whole number
[4]This unit is tractor harvest in Alternative 4 - see Table 66 for effects

Standard options to reduce the effects of ground-based equipment are to operate equipment when soils are snow covered, frozen, or dry (see Management Requirements in Chapter 2). Operating equipment under these soil conditions reduces the amount of detrimental soil disturbances. This practice is suggested in FSH 2509.18 – Soil Management Handbook. In addition, Alexander and Poff (1985) and Williams (1993) also recommended these options based on their field observations.

Soil disturbance from felling trees would be negligible and would be less than the natural amount of soil disturbance caused when trees are uprooted by wind. All trees would either be hand-felled towards the skid trails or, in the case of tractor units, would be mechanically-felled from the skid trails. Harvest activities are designed to minimize the

amount of soil disturbance off skid trails. Where skid trails already exist from previous activities, they would be reused where possible, thus reducing the amount of additional detrimental soil disturbance.

As displayed in Tables 65, 66, 70-72, all commercial and noncommercial vegetation treatments proposed in Alternatives 4 and 5 would meet Regional Soil Quality Standards, would not irreversibly damage soil slope or other watershed conditions, and would not result in substantial or permanent impairment of the productivity of the land.

Mitigation or restoration of detrimental conditions would be included as part of the unit treatment prescription (see Management requirements in Chapter 2), which would restore soil quality and land productivity to these treated acres.

Duration of Effects. Changes in soil bulk density (compaction) and surface soil displacement caused by implementing the action alternatives would be temporary (see previous Tables 58-61 and accompanying discussion). Natural processes such as freeze-thaw and root growth eventually loosen compacted soils. Where harvesting activities affect soil quality in excess of regional standards, management requirements would be implemented to assure restoration.

Mass Failure. Interpretations of the characteristics and behaviors of the soils and landforms in the project area contained in the Lolo Land Systems Inventory do not identify mass failure as a particular risk. Neither action alternative would affect the risk of mass failures.

Cumulative Effects – Action Alternatives

The main activities that have affected soils in the project area in the past include timber harvest and associated activities such as site preparation, fuel reduction, and road construction.

The temporal scale for assessing soil resource environmental effects includes both short- and long-term impacts. For the purposes of this analysis, short-term effects are defined as those that occur within about 10 years following proposed vegetation treatments. Long-term effects are defined as those that occur within about 10-20 years or more following proposed vegetation treatments. The appropriate geographic area for soil cumulative effects analysis has been defined as the “land area affected by management activity” (USDA Forest Service 1999). This is because soil productivity is a site-specific attribute of the land. The productivity of one area of soil is not dependent on the productivity of another area whether that area is adjacent or not. Similarly, if one acre of land receives soil impacts from management activities and a second management activity that may affect soil is planned for that same site, then soil cumulative effects are possible on that site. Thus, cumulative effects to soil productivity are appropriately evaluated on a site-specific basis. Evaluation of cumulative effects to soil productivity does not require an integrated “watershed-type” assessment. A larger geographic area such as a watershed or project area is not considered an appropriate geographic area for soil cumulative effects analysis. This is because assessing soil quality within too large an area can mask or “dilute” site-specific effects (Nesser 2001). Thus, cumulative effects to soils are evaluated for site specific activity areas (i.e., proposed vegetation treatment units), but are not evaluated for the entire watershed or project area. The total potential soil detrimental condition column presented in Tables 65, 66 and 70-71 reflect

cumulative effects to the soils of listed units (activity areas) as well as their direct and indirect effects.

Consistency with the Forest Plan and other Direction

Both action alternatives would be consistent with the Forest Plan. With the implementation of the management requirements, watershed restoration measures, and specific design criteria, proposed treatments in all activity areas would meet Regional Soil Quality Standards and Forest Plan Standards and Guidelines.

Fire, Fuels and Air Quality

Introduction

The Butte Lookout analysis area is located southwest of Missoula, Montana on the south side of Lolo Creek. The Lolo Creek Wildland-Urban Interface corridor is adjacent to the project areas northern border.

The proposed treatments are intended to improve the condition of the forest by: lowering the bark beetle risk, reducing ladder fuels and crown density, and lowering the risk of stand-replacement fire. These treatments would further improve forest health and recruit future old-growth. There are opportunities to feather or blend treatments with past regeneration cuttings.

Forest Plan Direction and Other Applicable Direction

Fire management activities considered in the action alternatives are consistent with direction in the Lolo National Forest Plan (1986) Chapter 2 Forest-Wide Management Direction, Management Area Standards as described below. Fire Management activities considered in the action alternatives are consistent with the Lolo National Forest Fire Management Plan (2006-2007) Appendix X to the Lolo National Forest Plan (1986).

The following summarizes the most prominent Management Areas (MA) in the analysis area along with the standards relevant to fire and fuels management.

MA-16 (5,918 acres, 52% of project area) standards:

> #9. Wildfires will be confined, contained, or controlled as provided for by criteria and guidelines for each fire management unit in the Fire Management plan, described in Appendix X.
>
> To achieve management goals and objectives, prescribed burning may be planned and executed to maintain or restore the composition and structure of plant communities, or for hazard reduction purposes.
>
> #25. Prescribed burning will be used to accomplish slash disposal, site preparation, silvicultural, ecological, wildlife and range objectives. In habitat groups where fire is not a useful tool, logging/scattering trampling, isolation of separate cutting units, fuel break construction, and fuel-wood utilization will be used to reduce fuel accumulations, reduce hazards and prepare sites for regeneration. Slash disposal will be complete enough to provide for free movement of deer and elk or in the case of isolated units, small enough to avoid impacting major elk/deer through paths. Prescribed burning for natural vegetation enhancement will be prescribed by a certified silviculturist. Use of

prescribed fire for hazard reduction and site preparation will be based on an economic analysis. Utilize the most cost effective alternative that will meet the required resource objective.

MA 25 (1,027 acres, 9% of project area) standards:

#7. Wildfires will be confined, contained, or controlled as provided for by criteria and guidelines for each fire management unit in the Fire Management plan, described in Appendix X.

To achieve management goals and objectives, prescribed burning may be planned and executed to maintain or restore the composition and structure of plant communities, or for hazard reduction purposes.

MA 26 (1,323 acres, 12% of project area) standards:

#3. Wildfires will be confined, contained, or controlled as provided for by criteria and guidelines for each fire management unit in the Fire Management plan, described in Appendix X.

To achieve management goals and objectives, prescribed burning may be planned and executed to maintain or restore the composition and structure of plant communities, or for hazard reduction purposes.

MA 14. (1,023 acres, 10% of project area) standards:

#6. Wildfires will be confined, contained, or controlled as provided for by criteria and guidelines for each fire management unit in the Fire Management plan, described in Appendix X.

To achieve management goals and objectives, prescribed burning may be planned and executed to maintain or restore the composition and structure of plant communities, or for hazard reduction purposes.

Missoula County Interagency Fire Management Direction

The Missoula County Community Wildfire Protection Plan (2005) provides direction to reduce hazardous fuel concentrations on specified Federal lands adjacent to wildland-urban interface.

Analysis Area Boundary

The analysis area used for fire and fuels incorporates 11,446 acres within Marshall Creek, Cooper Creek and West Fork Butte Creek. This area includes Airshed 3A and Airshed 3A/M delineated by the Montana/Idaho Airshed Group. The Airshed boundaries expand beyond the analysis area boundary to manage prescribed fire smoke impact on communities.

Analysis Methods

The following tools and models were used to analyze the effects of the proposed activities on fire, fuels, and air quality:

FOFEM Version 5.21 (developed by Keane and others) is a First Order Fire Effects Model that provides a quantitative prediction of fire effects. FOFEM was used to analyze wildfire smoke emissions under a very dry, summer-time

burning condition. Indicators used to compare effects of alternatives include total PM 10 and PM 2.5 emissions.

Behaveplus 2.0.2 fire modeling system (developed by Andrews and others) was used to analyze surface wildfire behavior under a very dry, summer-time burning condition. Indicators used to compare effects of alternatives include fireline intensity (the rate of heat energy released during combustion per unit length of fire front) and flame length (the distance measured from the tip of the flame to the middle of the flaming zone at the base of the fire).

Fuel Modeling system (Anderson 1982) was used to select representative fuel models for the current condition, the effects of Alternative 4 and 5, and the anticipated conditions of Alternative 1 with time. Selected Fuel Models were used in the Behaveplus 2.0.2 fire modeling system.

Fire Group studies from Fischer and Bradley (1987) as applied to the Butte Lookout analysis area were used to examine fire's ecological role on forest succession in correlation with Fire Regime data.

National Historic Fire Regimes (Schmidt and others 2000) and Lolo NF, Butte Lookout analysis area Fire Regime data was used to examine the historic interrelationships of fire frequency and fire severity within the analysis area. This study assessed the current and anticipated conditions and the amount of deviation from historic Fire Regime that has and would continue to occur. Fire Regime data along with Behaveplus 2.0.2 data was used to examine the effects of alternatives on wildfire severity.

Existing Conditions

Historically, fire has played an important role in shaping the Butte Lookout area's vegetative landscape. Approximately 100 years ago much of the Butte Lookout analysis area experienced one or more fairly large, intense fire events. This fire history is evidenced by the current widespread representation of mostly even-aged mature lodgepole pine stands. Lodgepole pine is highly dependent on fire events for regeneration. More recently, fire suppression has restricted naturally occurring fire and limited the beneficial fire effects to the project landscape. Forest management has since recognized fire's critical function in long-term ecosystem health. Fire, either future wildfires or management-ignited prescribed burns, will continue to modify the landscape.

Fire history data for lower subalpine habitat types, which dominate the analysis area, reflect that almost 60 percent of the mature stands in western Montana on subalpine fir/beargrass habitat types showed obvious evidence of ground fire after establishment (Arno 1980). Periodic low-to moderate-severity fire favors Douglas-fir and lodgepole pine by setting back invasion by more tolerant subalpine fir and spruce, which in the absence of fire, form dense understories that eventually take over the site. Periodic fire would reduce ladder fuel and crown density thus lowering the risk of stand-replacement fire via sustained crown fire. Restoring a patchwork of various stand structures would provide further influence on wildfire intensity and spread.

Forest fuel conditions in the Butte Lookout analysis area have been affected by fire suppression, past timber management treatments, and mountain pine beetle infestations. Current fuel conditions are evolving towards substantial increases in

surface fuel loading. The effects of the current, widespread mountain pine beetle infestation will generate considerable additions to surface fuel loading impacting increasingly larger portions of the project area.

Past Fire Suppression

The Lolo National Forest Fire Management Plan (2006-2007) indicates from 1996 to 2005 the Lolo averaged 178 wildfires per year that burned an average 16,136 acres annually. Less than 2 percent of these wildfires escaped initial attack and became large fires. At mid-elevations typical of the Butte Lookout analysis area, the Lolo averages 55 wildfires per year burning 8,142 acres annually. Thirty-one percent of the suppression workload occurs within these mid-elevation sites. The wildland-urban interface (WUI) averaged 108 wildfires per year that burned 3,819 acres annually. Sixty-one percent of the suppression workload occurs in the WUI. High elevation, remote fires averaged 15 wildfires per year that burned 4,175 acres annually. High elevation fires account for 8 percent of the suppression workload.

Fire suppression over the past 80 years has reduced naturally occurring fire events and limited beneficial fire effects over the project landscape. These natural fire events would have periodically reduced forest fuel concentrations helping to maintain a patchwork of various stand structures. In general, there would have likely been more fire spread occurrences in the northern portion at the lower elevations. The southern portions at higher elevations would have experienced fire starts, but fire spread would be limited to extended periods with dry conditions. Each of these naturally occurring fire events would have reduced forest fuel continuity to varying degrees based on fuel moisture, weather, and topography. These fires would have most likely killed the more shade-tolerant, less fire-resistant tree species and effectively thinned the forest. Fire would have recycled nutrients to the soil to stimulate both residual and new regeneration. Fire suppression has reduced the beneficial effects of low and mixed severity fire events that would have most likely promoted a widespread mosaic of stand structures. Since fire has not been allowed to burn, vegetation across the landscape is fairly homogeneous. Fuels are more continuous than was thought to exist under more natural fire regimes. Fire exclusion has lead to an overall increase in tree densities. This has increased the vertical and horizontal fuel continuity. Shade-tolerant tree species are becoming increasingly present and provide fuel ladders so future wildfire would be more likely to transition from the forest floor into the tree canopy.

Past Timber Management

Forest Service timber stand data records indicate prior to 1970 through the 1990s there have been approximately 1,626 acres of regeneration harvest and 1,182 acres of intermediate harvest within the Butte Lookout analysis area. During this period, prescribed fire was applied to approximately 589 acres. Since the 1970s prescribed fire acreage has declined with each decade. Past harvest units are widely distributed over the project area and some are near or adjacent to the proposed units. Previous timber management activities have reduced fuel loading in some areas and increased fuel load diversity in the project area. This fuel loading mosaic would likely affect future wildfire behavior as fire spreads over the landscape. Previously harvested stands have regenerated and are now stocked with vigorous western larch and lodgepole pine. Wildfire burning in the majority of these areas would likely be low intensity surface fires with minimal severe fire effects. The combined effects of past timber management

treatments, partially mimics fire's natural role (i.e., moderate to stand-replacement severity fire events) by reducing fuels in areas and generating stand age diversity over the analysis area.

Mountain Pine Beetle

Mature, mostly even-aged lodgepole pine predominate many areas within the Butte Lookout analysis area. This mature successional condition puts lodgepole pine stands at high-risk and susceptible to mountain pine beetle infestations. Mountain pine beetle infestations are currently well-established within the analysis area. Without treatment, mountain pine beetle will most likely cause widespread lodgepole pine mortality over large portions of the project area, significantly contributing to fuel loading.

The current mountain pine beetle infestations affect fuel configurations and wildfire behavior. Mountain pine beetles kill and defoliate mature lodgepole pine, and infested areas would initially have a decreased probability for crown fire development and spread. However, there would be a short-term, minor increase in fine surface fuels from the defoliation. With time, the dead standing lodgepole pine would fall in a random jack-straw pattern. Mountain pine beetle's preference for large diameter trees would dramatically increase surface fuel loading. The most likely increase would be in dead woody material greater than 3 inches in diameter. In approximately 5 to 20 years the biomass arrangement would shift from a vertical to a horizontal distribution creating a fuel bed conducive to fire spread (Armour 1982). The down dead lodgepole pine would likely be intertwined and partially suspended from the forest floor. This suspended fuel arrangement combined with the dry cool climate and the decay resilient nature of lodgepole pine would make this increased fuel load condition persist for many years. As more lodgepole pine fall, more shade-tolerant species regeneration would increase. The combined effect of large down dead material and fine live fuels from shade-tolerant tree species would significantly increase fuel continuity and fuel loading along the forest floor.

Under extended dry conditions, wildfire in this fuel configuration would most likely have extremely high fire intensities. These high intensity fires would likely eliminate even tree species generally more resistant to fire damage than lodgepole pine such as Douglas-fir and western larch, returning the area to mostly pure lodgepole pine (Amman 1977, Amman 1991). As a wildfire spreads, fire behavior from these events would likely affect adjacent vigorous healthy stands not affected by mountain pine beetle. This condition would likely increase the probability for crown fire development and mortality in nearby stands.

In summary, the scope of the mountain pine beetle infestation and its widespread influence on fuel loading will have a notable affect on future wildfire behavior in the Butte Lookout analysis area. Under hot dry summer conditions a wildfire in this projected fuel configuration could facilitate widespread intense fire behavior. Fire suppression will continue in this area, and suppression efforts will likely be successful in keeping fires small under most low to moderate weather conditions. This delays, but does not mitigate, a large intense wildfire under severe fire weather conditions.

Fire Groups

Fire Groups (Fischer and Bradley 1987) were used to assess landscape level fuels. The Missoula Ranger District generated a Fire Group map for the analysis area. Four Fire Groups are commonly represented in the Butte Lookout analysis area. Fire Group 6 is

more common at the lower elevations and Fire Groups 7, 8 and 9 are more frequent at the higher elevations. Habitat types are categorized into Fire Groups based on the response of the tree species to fire and the roles of these tree species during succession. The predominant analysis area Fire Groups are defined below.

Fire Group Six. Fire Group Six is defined as moist Douglas-fir habitat types. Fire Group Six habitat types occur throughout western Montana at elevations of about 3,000 to 6,500 feet. Douglas-fir is both the indicated climax species and a vigorous member of seral communities. It is not uncommon for Douglas-fir to dominate all stages of succession on these sites even when subject to periodic fire (Fischer and Bradley 1987).

Fire history studies conducted in Fire Group Six in southwestern Montana indicate a mean fire interval of 42 years for pre-settlement stands (Arno and Gruell 1983). A tentative mean fire-free interval of 15.8 years was reported by Habeck (Crane and others 1983) near Missoula, Montana.

Historically, fire was an important agent in controlling density and species composition. Low-to moderate-severity fires converted dense stands of pole-sized or larger trees to a more open condition and subsequent light burning maintained stands in a park-like state. Frequent low or moderate fires favored larch and ponderosa pine over Douglas-fir in stands where these species occurred. Severe fires probably occurred on dense, fuel-heavy sites and resulted in stand replacement. Stand-replacement fires favored lodgepole pine on sites where this species was present. Fire's role as a stand-replacement agent becomes more pronounced when the natural fire-free interval is increased through fire suppression, unless corresponding fuel reduction occurs (Fischer and Bradley 1987).

Fire Group Seven. Fire Group Seven is defined as cool habitat types usually dominated by lodgepole pine. This group includes stands in which fire maintains lodgepole pine as a dominant seral species as well as those stands in which lodgepole is persistently dominant (Fischer and Bradley 1987).

Lodepole pine stands tend to have two stages in their life cycle that have elevated fire intensity potential. Young immature, dense stands with intertwining branches tend to have high fire intensity potential. As stands develop into and through the mature stage, the fire intensity potential decreases. During the mature stage, fuel continuity tends to be light and discontinuous. There is a progression to high fire intensity potential as the stands age. In the older stands, increasing lodgepole pine downfall significantly increases dead fuel loading along with establishment of shade-tolerant species (Brown 1975, Muraro 1971).

On sites below 7,500 feet, fire is a dominant agent that perpetuates or renews lodgepole pine. Without fire, shade-tolerant species replace lodgepole because it does not regenerate well on duff or under shaded conditions. Historically, fire would interrupt the course of succession and increase the proportion of lodgepole within each burn. Periodic fires may thin stands or otherwise rejuvenate them without doing serious damage. In stands greater than 60-80 years old, fuel build ups can be hazardous due to natural thinning, mountain pine beetle outbreaks, dwarf mistletoe infestations and fire-killed snags from previous fires (Lyon 1984).

Fire Group Eight. Fire Group Eight is defined as dry, lower subalpine habitat types. This is a collection of habitat types in the spruce and subalpine fir series that usually support mixed stands of Douglas–fir and lodgepole pine (Fischer and Bradley 1987).

Douglas-fir and lodgepole pine are dominant seral species, with lesser amounts of spruce and occasional larch or western white pine. The prevalence of Douglas-fir and lodepole pine may be due in part to periodic wildfire that sets back the invasion of subalpine fir and spruce (Fischer and Bradley 1987).

Stands are generally characterized by relatively large amounts of down woody fuels of all size classes, but especially large amounts of material greater than 3 inches in diameter. Live fuels can contribute significantly to the overall fire hazard during dry conditions. Dense understories develop in many stands and provide fuel ladders to the overstory trees' crowns. Relatively deep duff layers may form. When the duff is dry, fire can cause considerable mortality by heating the shallow roots of subalpine fir and Englemann spruce (Fischer and Bradley 1987).

Historically, periodic low-to moderate-severity fire favors Douglas-fir and lodgepole pine. These fires would set back invasion by the more shade-tolerant subalpine fir and spruce, which in the absence of fire form dense understories and eventually take over the site (Fischer and Bradley 1987).

Fire Group Nine. Fire Group Nine is defined as moist, lower subalpine habitat types. Fires are infrequent but severe in these types and the effects of fire are long-lasting. Spruce is usually a major component of seral stands (Fischer and Bradley 1987).

Forest succession in Fire Group Eight is similar to Fire Group Nine. Both groups share many of the same seral and climax tree species. The major difference between the two is that the drier Group Eight stands experience more frequent, generally less severe fires than Group Nine (Fischer and Bradley 1987).

Fire Group Nine fuels are similar to those found in Fire Group Eight. Down dead woody material on the forest floor averages about 25 tons per acre, but may be much higher. A large percentage of the down woody material is greater than 3 inches in diameter. The combination of deep duff and large amounts of dead rotten fuel can result in severe surface fire during unusually dry conditions. Where dense understories exist, fires can spread to the tree crowns. Without crowning there is a good chance the overstory trees would be killed by cambium heating. Under normal moisture conditions a lush undergrowth of shrubs and herbs usually serves as an effective barrier to rapid fire spread.

Fire Regime

Fire occurs on the American landscape on a variety of time tables. Nationally, this variation of fire occurrence has been categorized into five historical fire regimes (Schmidt and others 2000) as displayed in Table 73 below and shown on the map located in Appendix B, document b-8. Fire Regimes provide historical interrelationships as to fire frequency and fire severity. Within the Butte Lookout analysis area, Fire Regime III (Fire Group 6) is represented at the lower elevations and Fire Regime IV (Fire Groups 7, 8, 9) is common at the higher elevations).

Table 73 National Historical Fire Regimes (Schmidt and others 2000)

Fire Regime	Frequency (Fire Return Interval)	Severity	Fire Group(s)
I	0-35 years-high frequency	Low-severity	2 and 4
II	0-35 years-high frequency	Stand-replacement	(Minimally present on the Lolo NF)
III	35-100 + years-moderate frequency	Mixed-severity	5 and 6
IV	35-100 + years-moderate frequency	Stand-replacement	7,8,9 and 11
V	> 200 years–low frequency	Stand-replacement	10

Generally, when fires burn more frequently, they tend to be low-intensity surface fires burning leaf and needle litter, dead branch material, down logs, bark, cones, and low growing plants. The larger overstory trees tend to survive the fire, and patches of unburned forest often remain. The more frequent the fire interval the more likely excess fuel is periodically consumed. Periodic fire has a long-term combined effect of reducing fuel loads in areas and reducing overall fire intensities for larger areas. Forests under this scenario tend to retain a long-term large tree overstory component on the site, with relatively fewer smaller understory trees.

In Fire Regimes where fire burns less frequently, fire intensity tends to be moderate to high. Over time, fuels accumulate and create both a vertical and horizontal continuity. Under dry conditions fire would spread rapidly and burn with high severity.

Historically, the Butte Lookout analysis area likely experienced fire events at a moderate frequency with a fire return interval between 35-100 + years. These fire events would most likely be mixed-severity at lower elevation sites and stand-replacement severity at the higher elevations. Historical fire cycles have been modified with the advent of fire suppression. Long-term fire suppression has limited fire's natural role, as a periodic fuel reduction component of the forest. Fire exclusion promotes an escalating, continuous fuel arrangement, increasing the likelihood for high wildfire severity. A wildfire burning under hot summer time conditions in these forest conditions has a far greater likelihood of being much more severe than historic fires.

Environmental Consequences
Alternative 1
Direct and Indirect Effects

Alternative 1 would affect future wildfire behavior because there would be no harvesting or prescribed fire. There would be an overall continuing decline in forest health due to unnaturally excess biomass and a continued absence of beneficial fire effects. Under hot dry summer conditions the effects of Alternative 1 would promote an increasing likelihood of large, severe wildfire behavior. In mixed conifer stands the probability of torching and crowning would increase as shade-tolerant ladder fuels proliferate over the area. There would be an increasing likelihood of crown fire development and sustained crown fire spread with each fire season in the mixed conifer types. Mountain pine beetle preference for large diameter lodgepole pine would dramatically increase fuel loading over large portions of the analysis area. Within approximately 5 to 20 years, mature lodgepole pine biomass arrangement would shift from a vertical to a horizontal

distribution, creating a heavy, dead, woody, surface fuel-bed conducive to intense fire spread (Armour 1982).

During low to moderate fire danger, fire suppression efforts would likely be effective. Under extended periods of high fire danger there would be an increasing potential for large fire growth and severe fire effects. Crown fire development and sustained intense surface fire would be more likely during these hot, dry periods with each season. Firefighters and the public would be exposed to larger more intense wildfires. Fire suppression cost would increase as tactical efficiency and effectiveness would decline. Severe wildfire generated inside the project area would threaten resources farther up the drainage and impact the adjacent WUI.

Fire managers use 13 fuel models to aid in fire behavior predictions. These fuel models are organized into four groups: grass, shrub, timber and slash. Four fuel models are common in the analysis area. Current fuel conditions in the majority of the proposed treatment units are comparable to fuel model 8 with small intermixed pockets of fuel models 2, 9 and 10. Fuel model 8 areas are likely to transition to fuel model 10 conditions. This progression toward fuel model 10 conditions would occur due to the effects of mountain pine beetle lodgepole pine mortality, increasing shade-tolerant tree species in the understory, and continued fire suppression. Lodgepole pine stands with mountain pine beetle infestation would most likely shift from a mostly vertical fuel arrangement with low wildfire intensity potential to a significantly increased horizontal fuel load arrangement with high wildfire intensity potential. Continued fire exclusion would facilitate shade-tolerant tree species establishment in the understory throughout the analysis area. This combined influence of increasing dead and live surface fuel loading would likely result in fewer areas with fuel model 8 conditions and more areas with fuel model 10. There would be an increasing potential for severe wildfire behavior. Wildfires in fuel model 10 tend to be at the upper limit of control by direct attack. With increased winds and drier conditions torching, crowning, and spotting is more frequent in this fuel situation making a large high intensity wildfire more likely (Anderson 1982). Table 74 summarizes fuel model characteristics represented in the analysis area.

Table 74 Fuel Model Characteristics Represented in the Butte Lookout Analysis Area

Fuel Model	FM 2	FM 8	FM 9	FM 10
Total fuel load < 3 inch dead and live (tons/acre)	4.0	5.0	3.5	12.0
Dead fuel loading, ¼ inch (tons/acre)	2.0	1.5	2.9	3.0
Live fuel load, foliage (tons/acre)	0.5	0.0	0.0	2.0
Source: Aids to Determining Fuel Models for Estimating Fire Behavior (Anderson 1982)				

As discussed previously, the Behaveplus 2.0.2 fire modeling system (Andrews and others) was used to analyze surface fire behavior of typical current and projected fuel conditions in the analysis area. The Behaveplus 2.0.2 Model is not an absolute representation of fire behavior, but is a relative indicator of fire behavior that can aid land managers in the decision making process. Limitations of this model run results include weather and topographic variables that would likely occur as a fire spreads over time and space.

Behaveplus runs were generated to compare current and future potential fire behavior assuming no treatment is applied to proposed units. Fuel model 8 was used to represent a typical, current fuel condition were the majority of the biomass is standing, surface fuel loading is light, and ladder fuels are minimal. Fuel model 10 reflects the

anticipated, fuel transformation as stand vigor declines with time. Fuel model 10 depicts a biomass shift from vertical to horizontal with increased surface fuel loading and ladder fuels.

Behaveplus input parameters that were used characterize dry, late summer, high fire danger conditions. Input parameters were: 70–foot lodgepole pine; 0.2 crown ratio; live woody fuel moisture 50%; fuel moistures: 1-hour = 4%, 10-hour = 5%, and 100-hour = 6%; mid-flame wind speed 0-10 mph; air temperature 70 º Fahrenheit; and a 45% slope.

As shown in Table 75, analysis results indicate, under the same fuel moisture, weather, and topography, fuel model 10 conditions generate notably more severe surface fire behavior than fuel model 8. Under high fire danger conditions, there would be a trend toward increased rate of spread, fireline intensity, flame length, scorch height, and a higher probability of mortality. With no treatment applied, increasing portions of the analysis area would acquire an increased likelihood for severe wildfire behavior.

Table 75 Comparison of Behaveplus Outputs for Fuel Models 8 and 10

Mid-flame wind speed (mi/hr)	Rate of Spread (ch[1]/hr)		Fireline Intensity (Btu/ft/sec)		Flame Length (ft)		Scorch Height (ft)		Probability of Mortality (%)	
	FM8	FM10	FM8	FM10	FM8	FM10	FM8	FM10	FM8	FM10
0.0	1.1	6.0	4	165	0.9	4.7	2	27	69	69
2.0	1.7	9.5	6	259	1.1	5.8	2	36	69	69
4.0	2.7	15.3	10	418	1.3	7.2	2	47	69	69
6.0	3.9	22.7	15	617	1.6	8.6	1	56	69	92
8.0	5.4	31.1	21	847	1.8	10.0	1	64	69	99
10.0	6.9	40.5	27	1104	2.0	11.3	1	70	69	100

[1] One Chain = 66 feet

FOFEM Version 5.21 (Keane and others) is a First Order Fire Effects Model computer program to aid resource managers, planners and analysts in predicting and planning for fire effects. FOFEM provides a quantitative prediction of fire effects. The FOFEM model was used to analyze wildfire smoke emissions in lodgepole pine under very dry conditions for current fuel load conditions and the anticipated increased fuel load condition. This analysis assumes no harvest treatment would be applied in the current or anticipated condition. The current condition reflects a typical mature lodgepole pine site with average down woody fuel loading were most of the trees are standing. The anticipated increased fuel load condition reflects mountain pine beetle induced lodgepole pine mortality and an increased shade-tolerant tree species component. Results indicate an overall increase in smoke emissions, primarily from smoldering combustion for all quantifiable outputs. As shown in Table 76 below, without harvest treatment it is likely future fuel conditions would trigger a noteworthy increase in wildfire smoke emissions.

Table 76 Summary of Results of FOFEM Model Execution for Alternative 1

Emissions	Current Condition (lbs/acre)	Anticipated Condition (lbs/acre)	Increase (%)
PM 10	963	1450	+66
PM 2.5	816	1229	+66
CH 4	494	745	+66
CO	10808	16307	+66
CO 2	47716	70112	+68

Alternative 4
Direct and Indirect Effects

In Alternative 4 the total proposed treatment area is 1,462 acres. Commercial harvest would occur on approximately 1,353 acres and of that, underburning would occur on approximately 704 acres. Ecosystem Maintenance Burning would occur on approximately 109 acres.

Alternative 4 includes underburning Cooper Creek units 17, 17A, 23, 24, 25, 28, 29, 31, 33, and 34. Underburning would occur in West Fork Butte Creek units 44, 45, 64, 65, 66, 66A, and 66B. unit 67 would be a 109 acre EMB.

The Cooper Creek burn units have a west aspect and would be ignited under spring or fall burning conditions. The West Fork Butte burn units have mostly a south aspect and would likely be ignited under spring burning conditions.

Alternative 4 would apply broadcast prescribed fire to approximately 813 acres or about 56% of the proposed treatment area. Prescribed fire would most likely distribute beneficial fire effects in a patchwork mosaic over each burn unit area. Broadcast burning would reduce surface fuel load concentrations, stimulate nutrient recycling, promote forest health, enhance and diversify wildlife habitat over areas. Areas broadcast burned would most likely serve as effective fuel-breaks to impede future wildfire spread.

Commercial harvest with no broadcast prescribed fire would occur over approximately 649 acres. These treatments would occur in Marshall Creek, Cooper Creek and West Fork Butte Creek incorporating about 44% of the proposed treatment area (see Appendix A Treatments).

Commercial harvest without broadcast prescribed fire would partially imitate natural fire events by reducing biomass in portions of units. Removing some merchantable trees would increase nutrient availability to a well-spaced, more vigorous overstory and a more open productive understory. This would also increase stand structural heterogeneity and habitat diversity within the analysis area. These treatments would reduce future wildfire severity by reducing vertical and horizontal fuel continuity. Given hot, dry summer conditions, the proposed treatments would affect wildfire behavior by reducing intense surface fire spread over the majority of the harvest unit areas. Isolated pockets of torching and crowning could occur but it is highly likely a fire would revert to a surface fire. There would be a greatly reduced likelihood of crown fire development and sustained crown fire spread. Future low-intensity wildfire events would be less detrimental and more beneficial to forest health. These treatments would collectively detour large-scale, severe wildfire spread over large portions of the project area.

Alternative 4 would reduce wildfire emissions by approximately 56% over 1,353 acres of commercial harvest treatments. The FOFEM model was used to compare wildfire smoke emissions, in lodgepole pine, under very dry, summer time conditions, for pre-harvest and post-harvest conditions. Output values are not absolute but do show a relative improvement with reduced wildfire emissions.

Table 77 Summary of Results of FOFEM Model Execution for Alternative 4

Emissions (Flaming and Smoldering)	Pre-harvest Wildfire (lbs/acre)	Post-harvest Wildfire (lbs/acre)	Emissions Reduction (lbs/acre)
PM 10	1066	470	596
PM 2.5	904	398	506

The biomass removed as a result of implementing Alternative 4 equates to approximately 400 tons of PM 10 and 342 tons of PM 2.5 that would not potentially impact the Missoula Valley.

Under Alternative 4, commercial harvest on 1,353 acres would modify fuel continuity and arrangement. This change would generate a change in fuel models from 8 to 11. In this analysis, fuel model 8 represents surface fuel conditions prior to harvest and fuel model 11 represents surface fuel conditions after harvest. However, the current mountain pine beetle activity within the analysis area is rapidly changing the high-risk lodgepole stands, which are targeted for treatment, from fuel model 8 to 10, which is the anticipated condition in the near future. The Behaveplus 2.0.2 fire model was used to compare surface wildfire behavior in lodgepole pine, under very dry, summer time, conditions for all three fuel models.

The Behaveplus 2.0.2 fire model outputs shown in Table 78 below demonstrate a dramatic increase in fireline intensity and flame lengths as the current stand evolves into a fuel model 10 from a fuel model 8. However, whole tree yarding over the 1,353 acres under Alternative 4 would result in a very light slash load as represented by fuel model 11. Of the 1,353 acres harvested and whole tree yarded, 704 acres would include the application of prescribed fire. Once these 704 acres were burned, wildfire intensity and flame lengths would be significantly less than those for fuel model 8 which would permit safe direct attack by firefighters.

Table 78 Behave-plus Outputs for Alternative 4

Fuel Model	FM 8 Pre-harvest		FM 10 No harvest		FM 11 Post-harvest	
Mid-flame Wind Speed (mi/hr)	Fireline Intensity (Btu/ft/sec)	Flame Length (ft)	Fireline Intensity (Btu/ft/sec)	Flame Length (ft)	Fireline Intensity (Btu/ft/sec)	Flame Length (ft)
0	4	0.9	165	4.7	46	2.6
2	6	1.1	259	5.8	79	3.4
4	10	1.3	418	7.2	120	4.1
6	15	1.6	617	8.6	165	4.7
8	21	1.8	847	10.0	211	5.3
10	27	2.0	1104	11.3	260	5.8

As discussed previously, output values are not an absolute but do show surface fire behavior trends. In this analysis, all fuel models indicate increased fire-line intensity and flame length with increased wind speed. For the remaining 649 acres that would be harvested but not burned, post-harvest values indicate a slight increase in fire-line intensity and flame length from pre-harvest condition. Fire behavior predicted for fuel model 11 would, for the most part, still is conducive to direct attack by suppression forces. As mentioned above, with time and no harvest, as the stands evolve into fuel model 10, a dramatic increase in both fire-line intensity and flame length occurs. These fuel model 10 conditions would surpass direct attack capabilities and stand-replacement

fire would be increasingly probable. Commercial harvest would facilitate a fire regime shift from stand-replacement severity towards low-to-mixed-severity on the 1,353 acres within the analysis area.

Alternative 5
Direct and Indirect Effects

In Alternative 5 the total proposed treatment area is 1,440 acres. Harvesting would occur on approximately 1,274 acres and of this, underburning would occur on approximately 668 acres. Ecosystem maintenance burning (EMB) would occur on approximately 166 acres.

Alternative 5 includes underburning in Cooper Creek on approximately 249 acres, (units 17, 17A, 23, 24, 25, 28, 29, 31, 33, and 34). These Cooper Creek burn unit areas are identical to those in Alternative 4. Approximately 419 acres would be under-burned in West Fork Butte Creek, (units 64, 65, 66 66A, 66B and 66C). There would be approximately 166 acres of EMB (units 44, 45, 47 and 67).

In West Fork Butte Creek, units 64, 66 and 66C total approximately 245 acres. Portions of these three units might not be feasible to harvest due to helicopter yarding distance limitations, in which case portions of these units would transition to EMB acreage.

The Cooper Creek burn units have a westerly aspect and would be ignited under spring or fall burning conditions. The West Fork Butte burn units have mostly a southerly aspect and would likely be ignited under spring burning conditions.

Alternative 5 would apply broadcast prescribed fire to approximately 834 acres or about 58% of the total proposed treatment area. Prescribed fire would most likely distribute beneficial fire effects in a patchwork mosaic over each burn unit area. Broadcast burning would reduce surface fuel load concentrations, stimulate nutrient recycling, promote forest health and enhance and diversify wildlife habitat over areas. Areas broadcast burned would most likely be effective fuel breaks to impede future wildfire spread.

Commercial harvest with no broadcast prescribed fire would occur over approximately 606 acres. These treatments would occur in Marshall Creek, Cooper Creek and West Fork Butte Creek incorporating about 42% of the proposed treatment area (see Appendix A Treatments).

As in Alternative 4, commercial harvest without broadcast prescribed fire would partially imitate natural fire events by reducing biomass in portions of units. Removing some merchantable trees would increase nutrient availability to a well-spaced, more vigorous overstory and a more open productive understory. This would also increase stand structural heterogeneity and habitat diversity within the analysis area. These treatments would reduce future wildfire severity by reducing vertical and horizontal fuel continuity. Given hot, dry summer conditions, the proposed treatments would affect wildfire behavior by reducing intense surface fire spread over the majority of the harvest unit areas. Isolated pockets of torching and crowning could occur but it is highly likely a fire would revert to a surface fire. There would be a greatly reduced likelihood of crown fire development and sustained crown fire spread. It is probable future low-intensity wildfire events would be less detrimental and more beneficial to forest health. These treatments

would collectively detour large-scale, severe wildfire spread over large portions of the project area.

Alternative 5 would reduce wildfire emissions by approximately 56% over 1,274 acres of commercial harvest treatments. FOFEM model outputs for Alternative 5 are shown in Table 79 below.

Table 79 Summary of Results of FOFEM Model Execution for Alternative 5

Emissions Flaming and smoldering	Pre-harvest Wildfire (lbs/acre)	Post-harvest Wildfire (lbs/acre)	Emissions Reduction (lbs/acre)
PM 10	1066	470	596
PM 2.5	904	398	506

The biomass removed as a result of implementing Alternative 5 equates to approximately 379 tons of PM 10 and 322 tons of PM 2.5 that would not potentially impact the Missoula Valley.

Under Alternative 5, commercial harvest over 1,274 acres would modify fuel continuity and arrangement resulting in a change in fuel models from 8 to 11. In this analysis, fuel model 8 represents surface fuel conditions prior to harvest and fuel model 11 represents surface fuel conditions after harvest. However, as in Alternative 4 the current mountain pine beetle activity within the analysis area is rapidly changing the high-risk lodgepole stands, which are targeted for treatment, from fuel model 8 to 10, which is the anticipated condition in the near future. The Behaveplus 2.0.2 fire model was used to compare surface wildfire behavior in lodgepole pine, under very dry, summer time, conditions for all three fuel models.

The Behaveplus 2.0.2 fire model outputs shown below demonstrate a dramatic increase in fireline intensity and flame lengths as the current stand evolves into a Fuel Model 10 from a Fuel Model 8. However, whole tree yarding over the 1,274 acres under Alternative 5 would result in a very light slash load as represented by Fuel Model 11. Of the 1,274 acres harvested and whole tree yarded, 668 acres would include the application of prescribed fire. The fireline intensity and flame lengths during prescribed burning would be less than the outputs for Fuel Model 11 as listed in Table 80 below. Once these 668 acres were burned, wildfire intensity and flame lengths would be significantly less than those for Fuel Model 8 which would permit safe direct attack by firefighters.

Table 80 Behave-plus Outputs for Alternative 5

Fuel Model	FM 8 Pre-harvest		FM 10 No harvest		FM 11 Post-harvest	
Mid-flame Wind Speed (mi/hr)	Fireline Intensity (Btu/ft/sec)	Flame Length (ft)	Fireline Intensity (Btu/ft/sec)	Flame Length (ft)	Fireline Intensity (Btu/ft/sec)	Flame Length (ft)
0	4	0.9	165	4.7	46	2.6
2	6	1.1	259	5.8	79	3.4
4	10	1.3	418	7.2	120	4.1
6	15	1.6	617	8.6	165	4.7
8	21	1.8	847	10.0	211	5.3
10	27	2.0	1104	11.3	260	5.8

As in Alternative 4, all fuel models indicate increased fireline intensity and flame length with increased wind speed. For the remaining 606 acres that would be harvested but not burned, post-harvest values indicate a slight increase in fireline intensity and flame length from pre-harvest condition. Fire behavior as predicted for fuel model 11 would, for the most part, still be conducive to direct attack by suppression forces. As mentioned above, over time with no harvest treatments (i.e., as the stands evolve into fuel model 10) a dramatic increase in both fireline intensity and flame length occurs. These fuel model 10 conditions would surpass direct attack capabilities and stand-replacement fire would be increasingly probable. Commercial harvest would facilitate a fire regime shift from stand-replacement severity towards low-to-mixed-severity on the 1,274 acres in the analysis area.

Alternative 4 and 5
Direct and Indirect Effects

The Lolo NF, Missoula Ranger District would manage all prescribed burning associated with the Butte Lookout project. All prescribed burn ignition would be managed in accordance with the Montana/Idaho Airshed Group, in conjunction with the Missoula County Health Department to mitigate the potential smoke impact. This includes all Ecosystem Maintenance Burns (EMB), under burns, and landing pile burning associated with this project.

The Butte Lookout analysis area boundary includes both Airshed 3A and Airshed 3A/M (Missoula Impact Zone). There are 15 units in Sections 2 and 11, located in Airshed 3A/M. The remaining project units are located in Airshed 3A. All EMB and underburning would occur in Airshed 3A. Landing pile burning would occur in Airshed 3A and 3A/M.

Prescribed wildland burning is allowed in Airshed 3A from March 1 to November 30 each year. Of this time, March through May generally afford the highest probability for understory prescribed burning approval by the Airshed Group. This is generally due to traditional springtime atmospheric instability which disperses prescribed fire smoke more readily and results in less residual smoke effect on the human populations. Little or no prescribed wildland burning is done in the summer months due to the increased risk of escape and wildfire season commitments. The fall months traditionally offer limited understory burning opportunities in Airshed 3A and especially Airshed 3A/M due to potential smoke impacts particularly at lower elevations. The later fall months traditionally offer some days where pile burning can be accomplished within air quality requirements.

Missoula Ranger District Fire Management staff would prepare Prescribed Burn Plans for broadcast burn units included in the Butte Lookout project. Adjoining project units with similar silvicultural prescribed fire objectives would likely be grouped into one burn unit. The Prescribed Burn Plan would include ignition parameters specific to the burn unit. A Maximum Manageable Area (MMA) would be delineated for each burn unit as each Prescribed Burn Plan is developed. Delineating an MMA during Prescribed Burn Plan development would more likely capture possible physiographic and environmental events that may significantly influence the prescribed fire fuel landscape in the interim. Environmental events that could influence the MMA may include extensive mortality, widespread blow-down, or large-scale wildfire.

The Butte Lookout broadcast burn MMA would likely be large in size in relation to its corresponding burn unit acres. A burn unit's MMA begins at the burn unit boundary and radiates outward to a Maximum Manageable Area Boundary. These areas would encompass National Forest System lands containing natural barriers that hinder fire spread under the specified prescribed fire parameters. Prescribed-ignition fire spread from the burn unit to the MMA would be monitored and acceptable but not promoted. Fire spread rate and intensity would likely decline in the MMA as it leaves the proximity of the burn unit, and it would be influenced by areas with cooler temperatures, higher relative humidity, and less available fuel. Fire spread in the MMA would most likely be isolated, low-intensity fire feathered onto lands adjacent to the burn units. The prescribed fire effect would likely result in burn area perimeters being less linear and more mosaic in nature. If fire spread outside the MMA boundary, the prescribed fire would become a wildfire and Fire Management staff would take appropriate suppression action.

There would be a risk of escaped prescribed fire under this proposed project mainly when broadcast prescribed burning. Risk of an escape would be mitigated by adhering to the approved prescribed burn plans that define optimal fuel moistures, air temperatures, humidity, wind spread and direction, air quality, and necessary personnel requirements.

Based on experience from past prescribed burning activities, springtime ecosystem maintenance burning (EMB) would likely consume some fine and smaller diameter woody surface fuels. Shrubs would likely be top-killed. Isolated torching and crowning would be possible but not likely. Fire effects would likely be more common on sites where more sunlight reaches the forest floor. Springtime EMB fire spread would be less probable in areas with dense canopy and greater surface shading. Prior to ignition, slashing small diameter material may occur in areas to facilitate EMB fire spread. Mostly homogeneous prescribed fire effects would likely be scattered over the burn unit area.

Harvest treatments would likely facilitate low-intensity, surface fire spread and increase fire effects distribution over areas. Litter layer consumption would likely be variable. The duff layer would likely not burn. Homogeneous and some diverse prescribed fire effects would likely be well-distributed over the burn unit area.

Fall underburning would likely consume litter and duff layers to variable degrees in a mosaic pattern over most of the burn unit. Most fine and small woody surface fuels would likely be consumed or partially burned. Large down woody material would likely be partially burn or consumed. Isolated torching and crowning would be possible. Diverse prescribed fire effects would likely be widespread over burn unit area.

Harvest treatments would generate landing piles under both Alternatives 4 and 5. Landing piles would be burned in the late fall during designated favorable air dispersion days and weather conditions conducive to burn pile containment.

Alternative 1, 4 and 5 - Cumulative Effects

Alternatives 1, 4 and 5 would have no effect on the quantity of lightning or human-caused wildfire starts. Lightning and human-caused wildfires will continue to influence the Butte Lookout landscape. It is likely Lolo NF Fire Management Staff will continue to prioritize this area with an initial attack suppression strategy. A wildfire expanding beyond initial attack suppression strategy would be followed by Fire Management Staff

implementing an Appropriate Management Response strategy. It is highly unlikely wildfire would be allowed to burn unabated in this locality due to its high value resources and proximity to the Lolo Creek WUI. Although naturally occurring wildfire events could possibly produce positive beneficial fire effects over the landscape, the Forest Service's liability, risk to resources, and threats to the public would likely compound.

The Lolo NF Fire Management Plan (2006-2007) geographically delineates three, Fire Management Units (FMU). Each FMU has associated values and risk that determine the appropriate management response. The Butte Lookout analysis area is located in FMU-2. FMU-2 objectives include: suppressing all wildfires using rapid, aggressive initial attack to control 95-97 percent of all wildfires; ensuring 15-30 percent of the annual hazardous fuel acres treated are in FMU-2; and 30-35 percent of those acres are treated using mechanical methods. FMU-2 areas are second priority for assigning initial attack suppression resources and hazardous fuel treatments, following FMU-1 areas.

The northern border of the Butte Lookout analysis area is adjacent to the Lolo Creek Wildland-Urban Interface (WUI). The Lolo Creek WUI is designated as FMU-1. FMU-1 objectives include: suppress all wildfires using rapid, aggressive initial attack to control 96-98 percent of all wildfires; ensure 70-85 percent of the annual hazardous fuels acres treated are in FMU-1; and 30-35 percent of those acres are treated using mechanical methods. FMU-1 areas are the first priority for assigning initial attack resources and hazardous fuel treatments.

Lolo Fire Management staff have long-recognized the potential wildfire control complexities associated with the typical FMU-2 landscape. FMU-2 commonly includes large areas with continuous, homogeneous fuels and potentially heavy continuous fuel loading. Mountain pine beetle epidemics frequently perpetuate heavy continuous surface fuel loading. High-intensity, stand-replacement wildfire behavior is probable with these fuel conditions. These areas can be extremely prone to torching, crowning, and spotting making fire control exceedingly difficult (Lolo NF Fire Management Plan 2006-2007, Lolo NF Ecosystem Maintenance Burning Guide).

Alternative 4 and 5 - Cumulative Effects

Alternatives 4 and 5 would likely promote forest health, distribute beneficial fire effects, and be advantageous to wildfire suppression efforts. Proposed treatments would create areas with a more vigorous, healthy, heterogeneous vegetative component adding biodiversity to the project area. National Forest System lands, adjacent WUI, Plum Creek Timber lands, and State of Montana lands would most likely accrue a positive cumulative effect due to a reduced likelihood for large-scale severe wildfire impact. Alternatives 4 and 5 would facilitate a similar fire regime shift from stand-replacement towards low-to-mixed wildfire severity. The collective effect of treatments would likely emulate fire's natural role, which has been absent in the recent past, over the analysis area. Smoke produced by prescribed burning would be regulated and managed to minimize potential impacts, while wildfire smoke production would likely be reduced. There would be a reduced risk from wildfire to firefighters and the public. Fire suppression cost would likely decrease as tactical efficiency and effectiveness would improve.