CHAPTER 4. CONSULTATION AND COORDINATION

Preparers and Contributors

The Forest Service consulted the following individuals, Federal, State, and local agencies, and non-Forest Service persons during the development of this environmental assessment:

FEDERAL, STATE, AND LOCAL AGENCIES:

US Fish and Wildlife Service, Helena

US Environmental Protection Agency, Helena
Montana Fish, Wildlife and Parks, Bozeman
City of Bozeman Commission
City of Bozeman Staff
Gallatin County Commission
Montana Department of Natural Resources, Bozeman
Rae and Sourdough Fire Departments

ORGANIZATIONS:

Bozeman Watershed Council

Greater Yellowstone Coalition

RY Lumber
Montana Wilderness Association
Native Forest Network
Native Ecosystems Council
Wilderness Society
American Wildlands

ID TEAM MEMBERS:

Teri Seth	NEPA Coordinator
Bev Dixon	Wildlife Biologist
Pam Brown	Forester
Mark Novak	Silviculturist
Tim Brickell	Fire Specialist
Bruce Roberts	Fisheries Biologist
Jane Ruchman	Landscape Architect
Henry Shovic	Soil Scientist

Mark Story	Hydrologist
Dave Cary	Recreation Specialist
Jim Devitt	Forest Planner
John Councilman	Forester

Distribution of the Environmental Impact Statement ___

This environmental impact statement has been distributed to individuals who specifically requested a copy of the document. In addition, copies have been made available for review at public libraries and at Forest Service offices and on the Gallatin Nation Forest web site. Copies have been sent to the agencies, State and local governments, and organizations listed above.

Glossary

Active Crown Fire: A **crown fire,** also called **running** an**d continuous crown fire,** is one in which the entire **fuel complex** becomes involved, but the crowning phase remains dependent on heat released from the **surface fuels** for continued spread. This type of fire is very difficult to suppress, flame lengths are usually over 6 feet, fire intensities are high.

Available Canopy Fuel: The mass of **canopy fuel** per unit area consumed in a crown fire. There is no post-frontal combustion in canopy fuels, so only fine canopy fuels are consumed. It is assumed that only the foliage and a small fraction of the branchwood is available.

Available Fuel: The total mass of ground, surface and canopy fuel per unit area consumed by a fire, including fuels consumed in postfrontal combustion of duff, organic soils, and large woody fuels.

British Thermal Unit (BTU): A unit of heat equal to 252 calories; quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Canopy Base Height: The lowest height above the ground at which there is a sufficient amount of **canopy fuel** to propagate fire vertically into the canopy. Canopy base height is an effective value that incorporates ladder fuels such as shrubs and understory trees. See also **fuel strata gap** and **crown base height**.

Canopy Bulk Density: The mass of **available canopy fuel** per unit canopy volume. It is a bulk property of a stand, not an individual tree.

Canopy Closure: The degree to which the canopy, forest layers above one's head, blocks the sunlight or obscures the sky. It can only be determined from measurements taken under the canopy as openings in the branches and trees must be accounted for.

Canopy Fuels: The live and dead foliage, live and dead branches, and lichen of trees and tall shrubs which lie above the **surface fuels.** See also **available canopy fuel**.

Chain (CH): Measure of length equivalent to 66 feet, 100 links or 20.1 meters.

Commercial Thinning (com) would occur in a previously thinned mixed specie stand. Remove LPP with dwarf mistletoe rating of 4 or more. Remove Engelmann Spruce (ES) and Subalpine Fir (SAF) to promote the dominance of DF. The result would be an open stand dominated by Douglas fir with LPP, ES and AF present in the stand. There may be an increased presence of aspen, which provides a more fire resistant forest type adjacent to the home. Where needed to meet spacing guidelines, pockets of intermediate trees including ES, DF and SAF would remain on site. After treatments, the spacing between crowns would be approximately 13’.

Removal of forest products from the forest for commercial use usually involves felling trees four inches or larger in diameter. Removal may involve use of wheeled or tracked vehicles for skidding and loading of trees. Other means of felling and removal may involve a feller buncher or similar type of equipment. Expected tree spacing post thinning would be approximately 13 feet between tree trunks.

Condition Class: Three ***Condition Classes*** have been developed to categorize the current condition with respect to each of the five historic Fire Regime Groups. Current condition is defined in terms of departure from the historic fire regimes, as determined by the number of missed fire return intervals- with respect to the historic fire return interval- and current structure and composition of the system resulting from alterations to the disturbance regime. The relative risk of fire-caused losses of key components that define the system increases for each respectively higher numbered condition class, with little or no risk at the Class 1 level.

Condition class 1 – Fire regimes are within a historical range and the risk of losing key ecosystem components is low. Vegetation attributes (species composition and structure) are intact and functioning within a historical range.

Condition class 2 – Fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one or more return intervals (either increased or decreased). This results in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetation attributes have been moderately altered from their historical range.

Condition class 3 – Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size, intensity and severity, and

landscape patterns. Vegetation attributes have been significantly altered from their historical range.

Conditional Surface Fire: A potential type of fire in which conditions for sustained active crown fire spread are met but conditions for crown fire initiation are not. If the fire begins as a surface fire then it is expected to remain so. If it begins as an **active crown fire** in an adjacent stand, then it may continue to spread as an active crown fire. Conditional surface fire is based more on higher flame lengths and rates of spread than a surface fire. Under desirable conditions: higher wind speeds, higher temperatures, lower relative humidity, and steeper slope could push a surface fire up to passive to active crown fire.

Continuous Crown Fire: See **active crown fire**.

Crown Base Height: The vertical distance from the ground to the bottom of the live crown of an individual tree. See also **canopy base height.**

Crown Bulk Density: The mass of available fuel per unit crown volume. Property of an individual tree, not a whole stand. See also **canopy bulk density.**

Crown Diameter: The length passing through the center of a tree's crown, from one side to the other.

Crown Fire: Any fire that burns in **canopy fuels.**

Crown Fire Hazard: A physical situation (fuels, weather, and topography) with potential for causing harm or damage as a result of crown fire.

Crowning Index: The open (6.1-m/20 ft) windspeed at which **active crown fire** is possible for the specified **fire environment**.

Dead and Down Material Cleanup: Includes hand piling dead and down material 3" diameter and less. The piles would be burned in the fall with snow cover on the ground or in the spring when soil moisture is higher.

Defensible Space: Defensible space is the area between a house and an oncoming wildfire where the vegetation has been modified to reduce the wildfire threat and to provide an opportunity for firefighters to effectively defend the house. Sometimes, a defensible space is simply a homeowner's properly maintained backyard. (NRCG-Living with Fire)

Duration of Fire: The length of time that combustion occurs at a given point. Relates closely to downward heating and fire effects below the fuel surface as well as heating of tree boles above the surface.

Ecosystem Process: The actions or events that link organisms and their environment, such as predation, mutualism, successional development, nutrient cycling, carbon sequestration, primary productivity, and decay. Natural disturbance processes often occur with some periodicity. (From Webster's dictionary, adapted to ecology)

Fire-Adapted Ecosystem: An eco-system with the ability to survive and regenerate in a fire-prone environment.

Fire Behavior: The manner in which a fire reacts to the influences of fuel, weather and topography.

Firebreak: A natural or constructed barrier to stop or check fires that may occur, or to provide a control line from which to work.

Fire Environment: The characteristics of a site that influence fire behavior. In fire modeling, the fire environment is described by surface and canopy fuel characteristics, windspeed and direction, relative humidity, and slope steepness.

Fire Event: See **Wildland Fire**. For the purposes of fuels analysis it is a wildfire, with a probability of occurrence, that is modeled using representative weather inputs (usually the 90th percentile) for the purpose of effects analysis to compare alternatives.

Fire Exclusion: The policy of suppressing all wildland fires in an area.

Fire Frequency (Fire Return Interval): A general term referring to the recurrence of fire in a given area over time. Sometimes stated as number of fires per unit time in designated area; also used to refer to the probability of an element burning per unit time. How often fire burns a given area; often expressed in terms of fire return intervals (e.g., fire returns to a site every 5-15 years).

Fire Groups:
Fire groups are defined as the dominant tree species and associated vegetation that responds in a similar fashion to wildland fire. The frequency and severity of a wildfire that typically occurred are key factors in identifying each fire groups. These are definitions of fire groups from "Fire Ecology of Montana Forest Habitat Types East of the Continental Divide, *Fisher and Clayton, 1983.*"

<u>Fire Group Seven</u> consists of cool habitat types usually dominated by lodgepole pine *(Pinus contorta)*. PICO climax type. Fire hazard is moderate for dense to open advanced immature and mature stands. The hazard increases as stands become over mature and ground fuels build up from downfall and established of shade tolerant species. Typical sources of deadfall in this fire group are snow mortality, mountain pine beetle attacks, wind throw of live trees and dwarf mistletoe-related mortality. If wildfires were not suppressed in this fire group stands would seldom reach a near-climax condition. Periodic

wildfires would recycle the stands before a substantial amount of mature Lodgepole pine died out. *Fischer and Clayton 1983 (pages 45-55)*

Fire Group Eight consists of dry, lower Subalpine habitat types where spruce or Subalpine fir is the climax species. Commonly a mixture of Douglas fir, Lodgepole pine and Engelmann spruce. Fire group eight usually produces a large amount of undergrowth commonly shrubs and forbs. In Subalpine fir habitat types, the live fuels can contribute to considerable increase in fire hazard during dry conditions. Dense understories develop and provide fuel ladders to the overstory tree crown, increasing chances of ground fires to climb to crown fires. *Fischer and Clayton 1983(pages 56-61)*

Fire Group Nine consists of a moist, lower Subalpine habitat type. These habitats occur at the moist and wet, lower elevations of the HBFR area. These habitats include the spruce and Subalpine fir with an abundant under story vegetation with dead down woody fuel exceeding 20 ton per acre. Historically, a mixed severity, mosaic burn occurred every 120 years, while severe or stand-replacing fire occurred in these habitats every 250 years on average. *Fischer and Clayton 1983 (pages 62-66)*

Fire Hazard: A fuel complex, defined by volume, type, condition, arrangement and location, that determines the ease of ignition and the resistance to control. A physical situation (fuels, weather, and topography) with potential for causing harm or damage, as a result of wildland fire.

Fire Intensity: See **frontal fire intensity**. Contrast with **fireline intensity**.

Fire Intensity Level (FIL): A measure of fire behavior used in the Interagency Initial Attack Assessment Model (IIAA) (a NFMAS term). It is based on the calculated flame length.

FIL 1: 0-2 feet
FIL 2: 2-4 feet
FIL 3: 4-6 feet
FIL 4: 6-8 feet
FIL 5: 8-12 feet
FIL 6: greater than 12 feet

The NFDRS Burning Index (BI) is calculated flame length x 10. FIL is used in the IIAA model as an indicator of fire danger for dispatch purposes, to categorize rate of spread, and in the assessment of fire effects. Each FIL has an associated suppression cost.

Fire Regime: Five combinations of fire frequency, expressed as fire return interval and fire severity, are defined (Table 1) to create the map of historic natural fire regimes. **Groups I** and **II** include fire return intervals in the 0-35 year range. **Group I** includes ponderosa pine, other long needle pine species, and dry site Douglas fir. **Group II**

includes the drier grassland types, tall grass prairie, and some chaparral ecosystems. **Groups III** and **IV** include the fire return intervals in the 35-100+ year range; and **Group V** is the long interval (infrequent), stand replacement fire regime.

Table 1

Fire Regime Group	Frequency (Fire Return Interval)	Severity
I	0-35 year	low severity
II	0-35 year	stand replacement severity
III	35-100+ year	mixed severity
IV	35-100+ year	stand replacement severity
V	>200 years	stand replacement severity

Fire Return Interval: Number of years between fires at a given location.

Fire Risk: Applies to the probability of an ignition occurring as determined from historical fire record data.

Fire Severity: A qualitative measure of the immediate effects of fire on the ecosystem. Relates to the extent of mortality and survival of plant and animal life both above and below ground and to loss of organic matter.

Fireline Intensity: The rate of heat release in the **flaming front** per unit length of fire front (Byram, 1959); can be converted to flame length. ($FL = 0.45*(I^{0.46})$). This expression is commonly used to describe the power of wildland fires.

Flame length: Measured in feet, helps predict initial attack methodology in fire suppression. Also helps figure the safety of direct or indirect attack for fire fighters or equipment. Flame length also helps predict the potential of fire moving up into the canopy of the trees. Flame length can also be defined as the length of the flame of a spreading surface fire within the flaming front. Flame length is measured from midway in the action flaming combustions zone to the average tip of the flames. Flame lengths of 0-4 feet can be directly attacked by wildland fire fighters. Flame lengths of 4 to 8 feet should be attached with indirect hand or hose control line and/or with equipment (engines, dozers); above 8 feet aerial support is needed to suppress the fire. Flame lengths above 4 feet will lessen the safety of firefighters and make suppression more difficult.

Flaming Front: The zone at a fire's edge where solid flame is maintained.

Foliar Moisture Content: Moisture content (dry weight basis) of live foliage, expressed as a percent. Effective foliar moisture content incorporates the moisture content of other canopy fuels such as lichen, dead foliage, and live and dead branchwood.

Fuel Break: A natural or manmade change in fuel characteristics which affects fire behavior so that fires burning into them can be more readily controlled.

Fuel Characteristics: Factors that make up fuels such as compactness, loading, horizontal continuity, vertical arrangement, chemical content, size and shape, and moisture content.

Fuel Complex: The combination of ground, surface, and canopy fuel strata.

Fuel Continuity: The degree or extent of continuous or uninterrupted distribution of fuel particles in a fuel bed thus affecting a fire's ability to sustain combustion and spread. This applies to aerial fuels as well as surface fuels.

Fuel Loading: Weight per unit area of fuel often expressed in tons per acre or tons per hectare. Dead woody fuel loadings are commonly described for small material in diameter classes of 0 to 1/4-, 1/4 to 1-, and 1 to 3-inches and for large material in one class greater than 3 inches.

Fuel Model: A set of surface fuel bed characteristics (load and surface-area-to-volume-ratio by size class, heat content, and depth) organized for input to a fire model. Standard fuel models (Anderson, 1982) have been stylized to represent specific fuel conditions.

Fuel model 10. Fire burns with more intensity in this fuel model than the other timber litter models. Dead and down fuels include greater quantities of 3 inch or larger wood resulting from over maturity or natural events that create a large load of dead material on the forest floor. Fuel build up in the form of ladder fuels that cause this fuel model to go from surface to crown fire. Crowning, spotting and torching of individual trees are more frequent in fm 10 which can lead to a faster rate of spread, higher flame length and larger acreage burned. Forest types in this fuel model can have a tight closed canopy with dead and down fuel loadings averaging 18 ton/acre. (Anderson, page 13)

Fuel model 8 areas support a slow-burning, lower intensity ground fire with low flame lengths which are less likely to move into the crowns of the trees. Trees are spaced father apart with an open canopy. This fuel model has minimal dead and down material, averaging 7 tons/acre. (Anderson, page 11)

Fuel Strata Gap: The vertical distance between the top of the **surface fuel** stratum and the bottom of the **canopy fuel** stratum.

Fuel Stratum: A horizontal layer of fuels of similar general characteristics. We generally recognize three fuel strata: ground, surface, and canopy.

Ground Fire: A slow-burning, smoldering fire in **ground fuels**. Contrast with **surface fire**.

Ground Fuels: Fuels that lie beneath surface fuels, such as organic soils, duff, decomposing litter, buried logs, roots, and the below-surface portion of stumps. Compare with **surface fuel**s.

Independent Crown Fire: A **crown fire** that spreads without the aid of a supporting **surface fire**.

Intermittent Crown Fire: A **crown fire** that alternates in space and time between active crowning and surface fire or passive crowning. See also **passive crown fire**.

Ladder Fuels: Shrubs and young trees that provide continuous fine material from the forest floor into the crowns of dominant trees.

Liberation Cut (lib): To remove the Dwarf Mistletoe infected overstory that remains. Areas that are heavily infected with Dwarf Mistletoe would be top priority for removal in this stand type. The **commercial product** would be post/pole and small sawlog. After treatments these stands would be an intermediate size/age stand with approximately 13' between tree crowns.

Litter: The top layer of the forest floor (01 soil horizon); includes freshly fallen leaves, needles, fine twigs, bark flakes, fruits, matted dead grass, and a variety of miscellaneous vegetative parts that are little altered by decomposition. Litter also accumulates beneath rangeland shrubs. Some surface feather moss and lichens are considered to be litter because their moisture response is similar to that of dead fine fuel.

Live Canopy Base Height: Is measured in feet is the height of the lower canopy of the trees. It is used in the equation for prediction if fire will climb up into the canopy and become a crown fire.

Mean Fire Return Interval: The arithmetic average of all fire intervals in a given area over a given time period.

Mechanical Harvest: Is use of machinery to implement a liberation cut (lib), a thin from below (tfb) or a commercial thin (com). The material identified for removal that meets specifications for a commercial product would be felled, skidded to landings, and hauled off site for commercial production. The stems boles and branches from the harvested trees left onsite would be machine piled. Machine piles would not exceed 10'x10'x10'. Following harvest the understory would be thinned to reduce ladder fuels. The focus of this treatment would be to reduce ladder fuels by slashing less desirable trees less than 4" in diameter. Remove trees = or < than 4" diameter unless a sapling or pole is needed to meet spacing guides of 13'x13'. Saplings less than 3' tall would be left. In general, in areas with continuous small trees, the small trees would be thinned to approximately 13'x13' spacing. Even though the entire acreage would be evaluated for this treatment need, the intensity of understory thinning would be less than in stands where no mechanical harvest is proposed. The slashed trees and natural fuels would be piled and burned in the fall. See also Thin from Below, Liberation Cut and Commercial Thin.

Mixed Severity Fire Regime: Regime in which fires either cause selective mortality in dominant vegetation, depending on different species' susceptibility to fire, or vary between understory and stand replacement.

Passive Crown Fire: A crown fire in which individual or small groups of trees torch out, but solid flaming in the canopy cannot be maintained except for short periods. Passive crown fire encompasses a wide range of crown fire behavior from the occasional torching of an isolated tree to a nearly active crown fire. Also called torching and candling. The increased radiation to surface fuels from passive crowning increases flame front spread rate, especially at the upper end of the passive crown fire range. Embers lofted during passive crowning can start a new fire downwind, which make containment more difficult and increases the overall rate of fire growth. Passive crowning is common in many forest types, especially those with an understory of shade-tolerant conifers. See also **intermittent crown fire**.

Percent Cover: Percentage of ground area that is directly covered with tree crowns. Generally, the crown area of a tree is computed using the formula for a circle as a function of crown radius or it is estimated in the field either visually or with a densiometer.

Plume-Dominated Fire: A fire for which the power of the fire exceeds the power of the wind, leading to a tall convection column and atypical spread patterns. Contrast with **wind-driven fire**.

Prescribed Burn/Prescribed Fire: Any fire ignited by management actions to meet specific objectives. A written approved prescribed fire plan must exist and NEPA requirements must be met, prior to ignition. This term replaces management ignited prescribed fire.

Predicted Spread Rate (ROS): is defined in chains per hour (Ch/Hr) 1 chain equals 66 feet. ROS is the rate the fire increases its horizontal dimensions. It can be surface or crown ros. ROS is driven by flame length, wind speed, amount and continuity of fuels for the fire to consume and topography. Heat intensity (BTU's) can play a role in heat transfer and supporting the fire. Predicted ROS is used for estimating the type of equipment and forces to use in suppression tactics. For example, one 3- person engine crew can fight a fire in fuel model 8 with flame lengths under 4 feet (direct hand or hose lay control line) at 15 chains per hour. In fuel model 10, one 3-person engine crew can fight fire with flame lengths over 4 feet (indirect hand and hose lay control line) 8 chains per hour.

Prescription: Measurable criteria that define the conditions under which a prescribed fire may be ignited, guide selection of appropriate management responses, and other required actions. Prescription criteria may include safety, economic, public health, environmental, geographic, administrative, social or legal considerations.

Probability: A number representing the chance that a given event will occur. The range is from 0% for an impossible event, to 100% for an inevitable event.

Purpose: An intended result, something for which an effort is being made (objective).

Risk: The possibility of meeting danger or suffering harm. When used relative to wildland fires, it refers to the probability of escape resulting in financial and ecological loss. Alternative management scenarios generate different degrees of risk and ultimately a different set of economic outcomes (Hesslin and Rideout, 1999).

Running Crown Fire: See **Active crown fire.**

Severity: See **Fire severity**.

Site Characteristics: The characteristics of a location that do not change with time: slope, aspect, elevation.

Slash Conifers, Lop & Scatter: Small conifer trees would be felled with a chainsaw to reduce fuel continuity in clumps and competition for aspen trees. The material would be cut to lengths shorter than 8' and have enough branches removed so the conifers are on the ground (lopping).The material would be scattered to increase fuel continuity to facilitate prescribed burning.

Stand Replacement Fire Regime: Regime in which fires kill or top-kill above ground parts of the dominant vegetation, changing the above ground structure substantially. Approximately 80 percent or more of the above ground dominant vegetation is either consumed or dies as a result of fires. Applies to forests, shrublands, and grasslands.

Stems Per Acres (stems/acre): The number of trees in an acre. Each tree is equal to one stem.

Structure Ignition Zone: see **Home Ignition Zone**.

Surface Fire: A fire spreading through surface fuels. A surface fire is one that burns in the surface fuel layer, which lies immediately above the ground fuels but below the canopy, or aerial fuels. Surface fuels consist of needles, leaves, grass, dead and down branch wood and logs, shrubs, low brush, and short trees. Surface fire behavior varies widely depending on the nature of the surface fuel complex.

Surface Fuels: Needles, leaves, grass, forbs, dead and down branches and boles, stumps, shrubs, and short trees.

Surfacing Index: The Surfacing Index is the open windspeed at which an **active crown fire** can be expected to drop to the surface, either due to insufficient **mass-flow rate** through the canopy or insufficient contribution of **surface fuels** to **fireline intensity**.

Thin From Below (tfb): Treatments would leave the larger & healthier Lodgepole pine (LPP) and other species when present. The treatment would begin to address the larger ladder fuels. Areas that are heavily infected with Dwarf Mistletoe would be top priority for removal in this stand type. The product would be post/pole and small saw log. After treatment this would be a mixed age Lodgepole Pine stand. The crown to crown spacing would be 13'x13'.

Threat: An indication of something impending. An expression of intention to inflict injury or damage.

Torching Index: The open (6.1-m/20 ft.) windspeed at which crown fire activity can initiate for the specified **fire environmen**t.

Understory Thinning: The focus of this treatment would be to reduce ladder fuels by slashing less desirable trees less than 4" in diameter. Remove trees = or < than 4" diameter unless a sapling is needed to meet spacing guides of 13'x13'. Saplings less than 3' tall would be left. Because of the mixed age composition of these areas there are extensive ladder fuels. These slashed trees and natural fuels less than 4" in diameter would be hand piled and burned in the fall. Hand piles would not exceed 6'x 6'x6'. The thinning would be accomplished using chainsaws.
Another distinction is that this material is not skidded or hauled by wheeled or tracked vehicles from the forest as logs or post and poles.

For both treatment types, natural fuels (fuels on the ground prior to this treatment) would be reduced to 10 to 15 tons per acre. Larger ground fuels would be reduced to not exceed 20 tons per acre total fuels. Gallatin Forest Plan direction for Snags (FP Amendment 14) and Down Woody Debris (FP Amendment 15) would be followed.

Value: See also **Values at Risk:** The monetary worth of something.

Values at Risk: Include property, structures, physical improvements, natural and cultural resources, community infrastructure, and economic, environmental, and social values. They may be on or off-site values.

Wildfire: An unwanted wildland fire. This is not a separate type of fire.

Wildland Fire: Any non-structure fire, other than prescribed fire, that occurs in the wildland. This term encompasses fires previously called both wildfires and prescribed natural fires.

Wildland Urban Interface: The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels.

Wind-Driven Fire: A wildland fire in which the power of the wind exceeds the power of the fire, characterized by a bent-over smoke plume and a high length-to-width ratio.

Wind Reduction Factor: The ratio of the midflame windspeed to the open (6.1-m/20 ft.) windspeed. For convenience of measurement, eye-level winds are usually substituted for midflame winds.

LITERATURE CITED

Referenced by Resource

Air Quality

Story, M. 2006. Air Quality Report (5/14/2007). Bozeman, MT. pp. 11

Story, M. 2006a. Air Quality Cumulative Effects Checklist (5/14/2007). Bozeman, MT. pp. 15.

Story M. and T. Dzomba. 2005. Describing Air Resource Impacts from Prescribed Fire on National Forests & Grasslands of Montana, Idaho, North Dakota, & South Dakota in Regions 1 & 4. 30 pp.
http://www.fs.fed.us/r1/gallatin/resources/air/guidance/index.shtml

Air Sciences, 2003. Users Guide Smoke Impact Spreadsheet (SIS). Portland, Oregon. http://www.airsci.com/SIS.htm.

Montana DSL, 1988, Montana Smoke Management, Memorandum of Agreement. p. D-15.

Elliott D.L., C.G. Holladay, W.R. Barchet, H.P. Foote, and W.F. Sandusky, 1986. Wind Energy Resource Atlas of the United States. US Department of Energy. p. 50.

USFS, 1994, BMP Review, Hyalite Wildlife Burn, 7/18/1994. Bozeman, Montana.

USFS, 1996, BMP Review, Bozeman Creek and Storm Castle Burns, 8/1/1996. Bozeman, Montana.

Amphibians

Bozeman Watershed Council. 2004. Sourdough Creek Watershed Assessment. Bozeman Watershed Council, Bozeman, Montana.

Roberts, B. 2007. Amphibian Report. Bozeman, MT. pp. 4.

Russell, K.R., Van Lear, D.H. and Guynn, D.C., 1999. Prescribed fire effects on herpetofauna: review and management implications. *Wildlife Society. Bulletin.* **27**, pp. 374–384.

Sullivan, Janet. 1994. Bufo boreas. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2007, January 19].

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences. 37:130-137.

Werner, J. L.. B. A. Maxell, P. Hendricks, and D. L. Flath, 2004, Amphibians and Reptiles of Montana. Mountain Press Publishing Company. Missoula, Montana.

Aquatics

Alexander, G.R., and E.A. Hansen. 1986. Sand Bed Load in a Brook Trout Stream. North American Journal of Fisheries Management. 6:0-23.

Bozeman Watershed Council. 2004. Sourdough Creek Watershed Assessment. Bozeman Watershed Council, Bozeman, Montana.

Chapman, D. W. and K. P. McCleod. 1987. Development of criteria for fine sediment in the northern Rockies ecoregion. Forest Service Files, Bozeman Ranger District, Bozeman, MT.

Cline R., G. Cole, W. Megahan, R. Patten, J. Potyondy. 1981. Guide for Predicting Sediment Yields from Forested Watersheds. U.S. Department of Agricultural, Forest Service, Northern Region, Missoula, Montana, and Intermountain Region, Ogden, Utah. pp 7-20.

Gallatin National Forest. 1990. Settlement Agreement to the Appeal of the Gallatin National Forest Plan by the Madison/Gallatin Chapter of trout Unlimited, Inc. U.S Department of Agricultural, Forest Service, Northern Region, Gallatin National Forest, Bozeman, Montana.

Gallatin National Forest. 2006. Gallatin National Forest Travel Management Final Impact Statement. U.S. Department of Agricultural, Forest Service, Northern Region, Gallatin National Forest, Bozeman, Montana.

Gamett, B.L. 2002. The Relationship between Water Temperature and Bull Trout Distribution and Abundance. Master of Science Thesis. Utah State University, Logan, Utah.

Hausle, D.A., and D.W. Coble. 1976. Influence of Sand in Redds on Survival and Emergence of Brook Trout (*Salvelinus fontinalis*). Transactions of the American Fisheries Society. 1:57-63.

Irving, J.S., and T.C. Bjornn. 1984. Effects of Substrate Size Composition on Survival of Kokanee Salmon and Cutthroat and Rainbow Trout Embryos. Completion Report. U.S. Department of Agricultural, Intermountain Forest and Range Experiment Station, Forest Service, Boise, Idaho. 21 p.

Leary, R., and J. Powell. 2007. Letter dated May 28, 2007 to Lee Nelson, Montana Fish, Wildlife and Parks, displaying westslope cutthroat trout genetic results from 2006. Montana Fish, Wildlife and Parks. Missoula, Montana. Pages 20.

MDNRC. 2002. Montana Guide to the Streamside Management Zone Law and Rules. Montana Department of Natural Resources and Conservation. Missoula, Montana.

Montana Fisheries Information System. 2006. Database Summary of Existing Fish Population Data Collected in Bozeman and Sourdough Creek Drainage. http://maps2.nris.mt.gov/scripts/esrimap.dll?name=MFISH&Cmd=INST Montana Fish, Wildlife and Parks. Helena, Montana.

Nelson, L. 2007. Fecundity Estimates from Several Westslope Cutthroat Trout Populations throughout the Upper Missouri River Basin. Montana Fish, Wildlife and Parks, Townsend, Montana. Unpublished Data.

Novak, M. 2007. Bozeman Municipal Watershed Fuels Reduction Project Specialist Report for Vegetation. U.S. Department of Agricultural, Forest Service, Northern Region, Gallatin National Forest, Bozeman, Montana.

Powell, B. E. 2002. Implementation of the 1999 Westslope Cutthroat Trout Conservation Agreement/MOU within the Upper Missouri River Basin. U.S. Department of Agricultural, Forest Service, North Region, Missoula, Montana. January 16, 2002. 2670.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow. 1993. Consideration of Extinction Risks for Salmonids. U.S. Department Agricultural. Forest Service, Intermountain Research Station. Boise, Idaho. FHR, No. 14.

Rieman, B. E., D. Lee, G. Chandler, and D. Myers. 1997. Does Wildfire Threaten Extinction for Salmonids: Response of Redband Trout and Bull Trout Following Recent Large on the Boise National Forest. Pages 47-57 in J. M. Greenlee, editor. Proceedings of the Symposium on Fire Effects on Threatened and Endangered Species and Habitats. International Association of Wildland Fire, Fairfield, Washington.

Roberts, B. 2007a. Aquatics Report. Bozeman, MT. pp.32.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Rosgen, D., and L. Silvey. 1998. Field Guide for Stream Classification. Wildland Hydrology. Pagosa Springs, Colorado.

Ruggerio, L.F., G. Hayward, and J. Squires. 1994. Viability Analysis in Biological Evaluations: Concepts of Population Viability Analysis , Biological Population, and Ecological Scale. Conservation Biology. 8(2):364-372.

Sestrich, C. M. 2005. Changes in Native and Nonnative Fish Assemblages and Habitat Following Wildfire in the Bitterroot River Basin, Montana. Master's Thesis. Montana State University, Bozeman, Montana.

Shepard, B.B., B. May, and W. Urie. 2003. Status of Westslope Cutthroat Trout (Oncorhynchus clarki lewisi) in the United States: 2002. Montana Fish, Wildlife and Parks and U.S.D.A, Forest Service.

Shovic, H. 2007. Bozeman Municipal Watershed Fuels Reduction Project Specialist Report for Soils. U.S. Department of Agricultural, Forest Service, Northern Region, Gallatin National Forest, Bozeman, Montana.

Story, M. 2007. Bozeman Municipal Watershed Fuels Reduction Project Specialist Report for Water Quality. U.S. Department of Agricultural, Forest Service, Northern Region, Gallatin National Forest, Bozeman, Montana.

Stowell, R., et al. 1983. Guide for predicting salmonid response to sediment yields in Idaho Batholith watersheds. U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, Montana, and Intermountain Region, Ogden, Utah. Pg. 17.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences. 37:130-137.

Witzel, L.D., and H.R. MacCrimmon. 1981. Role of Gravel Substrate on Ova Survival and Alevin Emergence of Rainbow Trout, *Salmo gairdneri*. Canadian Journal of Zoology. 59:629-636.

Bald Eagle

Dixon, B. 2007. Bald Eagle Report (May 1, 2007). Bozeman, MT. p. 4.

Greater Yellowstone Bald Eagle Working Group. 1996. Greater Yellowstone bald eagle management plan: 1995 update. Wyoming Game and Fish Department, Lander, WY

USDA Forest Service. 1987. Gallatin National Forest Plan. Bozeman, MT.

USDI Bureau of Reclamation. 1994. Montana Bald Eagle Management Plan. 104 pp.

Black Backed Woodpecker

Dixon, B. 2007a. Black Backed Woodpecker Report (revised May 9, 2007). Bozeman, MT. p.8.

Dixon, R. D., and V. A. Saab. 2000. Black-backed woodpecker (*Picoides arcticus*). No. 509. In Birds of North America. A. Poole, and F. Gill, editors. The Academy of Natural

Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, DC.

Hoffman, N. J. 1997. Distribution of Picoides woodpeckers in relation to habitat disturbance within the Yellowstone area. Master's thesis, Montana State University, Bozeman, Montana

Hutto, R .L. 1995. Composition of bird communities following stand replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9: 1041-1058.

Kotliar, N.B., S.J. Hejl, R.L. Hutto, V.A. Saab, C.P. Melcher, and M.E. McFadzen. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology No. 25: 49-64. *Cited in:* USDA 2007

Powell, H. D. W. 2000. The influence of prey density on post-fire habitat use of the black-backed woodpecker. Master's thesis, University of Montana, Missoula, Montana. *Cited in:* USDA 2007

Saab, V.A. and W. Block. 2006. Final report to the Joint Science Program, Project #01-1-3-25. Prescribed fire strategies to restore wildlife habitat in ponderosa pine forests of the Intermountain West. *Cited in:* USDA 2007

Saab, V. A., and J. G. Dudley. 1998. Responses of cavity-nesting birds to stand replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of Southwestern Idaho. USDA Forest Service Research Paper RP-11, Boise, Idaho.

Saab, V.A, and H.D.W. Powell. 2005. Fire and avian ecology in North America: Process influencing pattern. Studies in Avian Biology No. 30: 1-13. *Cited in:* USDA 2007

Samson , F. B. 2006. Habitat estimates for maintaining viable populations of the northern goshawk, black-backed woodpecker, flammulated owl, pileated woodpecker, American martin, and fisher. Unpublished report on file, Northern Region, Missoula, Montana.

Werner, R. A., and K. E. Post. 1985. Effects of wood-boring insects and bark beetles on survival and growth of burned white-spruce. Pages 14-16 *in* Early results of the Rosie Creek fire research project-1984. Agricultural Experiment Station Publication 85-2, University of Alaska, Fairbanks, Alaska. *Cited in:* USDA 2007

USDA Forest Service. 2007. Black-backed Woodpecker Northern Region Overview. Unpublished Report on file at USDA Forest Service Northern Region Office, Missoula, MT.

Fire and Fuels

Alberta Environment-Land and Forest Service. 1999. FireSmart: Protecting Your Community from Wildfire.

Anderson, Hal, 1982. Aids for Determining Fuel Models for Estimating Fire Behavior. General Technical Report INT-122.

Andrews, Patricia L., Bevins, Collin D., Seli, Robert C, 2005. BehavePlus fire modeling system version 3.0 Users Guide, RMRS-GTR 106WWW. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Beukema, S.J., E.D. Reinhardt, W.A. Kurz, and N.L. Crookston. 2000. Fire and Fuels Extension: Model Description. FFE-FVS. 80 pp.

Brickell, T. 2007. Fire and Fuels Report (05/07/07). Bozeman, MT. pp. 40.

Brickell, T. 2007a. Fire and Fuels Cumulative Effects Checklist (06/19/2007). Bozeman, MT. pp. 16.

Community Wildfire Protection Plan, DRAFT, March 2006. Gallatin County Montana. Map of Wildland Urban Interface areas.

Federal Departments and Agencies. 2001. Review and Update of the 1995 Federal Wildland Fire Management Policy. Chapter 1, Pages: 2-3. Obtain copy of report from Bureau of Land Management Office of Fire and Aviation at the National Interagency Fire Center. Boise, ID.

Finney, M.A. 1998. *FARSITE*: Fire Area Simulator, Version 4.1.052 - Model Development and Evaluation. USDA Forest Service, RMRS-RP-4.

Fischer, William C. and Bruce D. Clayton. 1983. Fire Ecology of Montana Forest Habitat Types East of the Continental Divide. USDA Forest Service, GTR INT-141. Ogden, Utah.

Fischer, C. William. 1981. Photo Guide for Appraising Downed Woody Fuels in Montana Forests. USDA, Forest Service; GTR INT-97 p 98,102,104. INT-98, pgs 16, 24, 36 and 52.

Fire Behavior Field Reference Guide, 1992. National Wildfire Coordinating Group, PMS 436-4.
Section VII, page 2.

Gallatin National Forest. 1987. Gallatin National Forest – Forest Plan. Pages: II-2, II-6, II-28. Gallatin National Forest. Bozeman, MT.

Graham, Russell T., Harvey, Alan E., Jain, Theresa B., Tonn, Jonalea R. 1999. The Effects of Thinning and Similar Stand Treatments on Fire Behavior in Western Forests. Page 1, 3, 22. USDA Forest Service, USDOI Bureau of Land Management; General Technical Report PNW-GTR-463.

Graham, Russell T., et al. 2004. Science Basis for Changing Forest Structure to Modify Wildfire Behavior and Severity. Pages 12, 17, 23, 24, 28, 29, 35. USDA Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-120.

Healthy Forests Initiative and Healthy Forests Restoration Act- *Interim Field Guide.* February 2004. USDA Forest Service, USDI Bureau of Land Management, FS-799.

Jones, Frederick C. 1995. Fire Assessment for the Madison Range Landscape. Page 13 and 14. Technical Fire Management Report. District Fire Management Officer, Gallatin National Forest, Bozeman, MT.

Keane, RE et al. March 1998. Development of Input Data Layers for the FARSITE Fire Growth Model for the Selway-Bitterroot Wilderness Complex, USA. USDA Forest Service, RMRS-GTR-3, Appendix G.

Lee Metcalf Wilderness Fire Management Guidebook. 1997. Gallatin and Beaverhead National Forest(s) with Dillon Resource Area, Bureau of Land Management. Chapter III, page 17 and Chapter I, page 1.

Leritz, Edward. 1996. Gallatin Project Fuels and Fire Severity Risk. Bozeman District Fire Management Officer. Gallatin National Forest. Bozeman, MT.

Losensky, John B. 1993. Fire History for Finnegan Ridge/Spanish Breaks. Bozeman Ranger District, Gallatin National Forest. Region One Draft Report. Forest Ecologist

Losensky, John B. 1993. Fire History for the Squaw Creek Drainage. Bozeman Ranger District, Gallatin National Forest. Region One Draft Report. Forest Ecologist.

National Fire Plan (NFP) 2000. "Managing the Impacts of Wildfires on Communities and the Environment – A Report to the President in Response to the Wildfires of 2000"; September 8, 2000.

National Interagency Complex Incident Management Organization Study, Findings and Recommendations. February 2005, p13.

National Wildfire Coordinating Group (NWCG), 2006. Glossary of Wildland Fire Terminology.
Available @ www.nwcg.gov/pms/pubs/glossary/

Omi, Philip N., Martinson, Erik J. 2002. Effect of Fuels Treatment on Wildfire Severity. Page 1, 25. Western Forest Fire Research Center, Colorado State University.

Partners in Protection. 1999. FIRESMART: Protecting your Community from Wildfire. Quality Color Press. Edmonton, Canada. Chapter 3, pages 2, 3 and 11.

Protecting People and Sustaining Resources in Fire-Adapted Ecosystems – A Cohesive Strategy. 2000. The Forest Service Management Response to the General Accounting Office Report GAO/RCED-99-65 (Oct. 13, 2000).

Raymond, Crystal L., and David L. Peterson, 2005. Fuel treatments alter the effects of wildfire in a mixed-evergreen forest, Oregon, USA. pg 2982 and 2992.

Rothermel, Richard C. 1983. How to Predict the Spread and Intensity of Forest and Range Fires. USDA Forest Service, GTR INT-143, 161 pgs.

Scott, Joe H., Reinhardt E.D. March 2005. Stereo Photo Guide for Estimating Canopy Fuel Characteristics in Conifer Stands. USDA Forest Service, RMRS-GTR-145, pgs.7, 15.

Scott, Reinhardt, 2001. Assessing Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior. RMRS-RP-29. U.S. Department of Agriculture, Forest Service; Rocky Mountain Research Station. 59pp.

Scott, Joe H., Burgan, Robert E. June 2005. Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model. USDA Forest Service, RMRS-GTR-153. pgs. 2,3,13,15,26,60.

Stratton, Richard D. 2004. Assessing the Effectiveness of Landscape Fuel Treatments on Fire Growth and Behavior. Journal of Forestry.

Tri-Data Corporation. October 1996. Wildland Firefighter Safety Awareness Study. Pg 181.

Elk and Other Big Game

Personal Communications Cited

Jourdonnais, Craig. Wildlife Biologist, Montana Fish Wildlife and Parks, Bozeman, Montana

Lemke, Tom. Wildlife Biologist, Montana Fish Wildlife and Parks, Livingston, Montana

Tyers, Dan. Wildlife Biologist, Gardiner Ranger District, USDA Forest Service.

Literature Cited

Bowyer, R.T., V.VanBallenberghe and J.G. Kie. 2003. Moose. Chapter 45. *In:* Wild Mammals of North America, Biology, Management, and Conservation. Second Edition. G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, Eds. The Johns Hopkins University Press. Baltimore and London.

Christensen, A.G., L.J. Lyon, and J.W. Unsworth. 1993. Elk Management in the Northern Region: Considerations in Forest Plan Updates or Revisions. Gen. Tech. Rep. INT-303. USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Dixon, B. 2007b. Elk and Other Big Game Report (revised may 10, 2007). Bozeman, MT. pp. 14.

Hillis, J.M., M.J. Thompson, J.E. Canfield, L.J. Lyon, C.L. Marcum, P.M. Dolan, and D.W. McCleery. 1991. Defining Elk Security: The Hillis Paradigm. *In:* Proceedings of a symposium on Elk Vulnerability. Montana Chapter, The Wildlife Society. Montana State University, Bozeman, Montana.

Lyon, L. J., T. N. Lonner, J. P. Weigand, C. L. Marcum, W. D. Edge, J.D. Jones, D. W. Mccleery and L. L. Hicks. 1985. Coordinating elk and timber management. Final report of the Montana cooperative elk-logging study 1970-1985. Montana Department of Fish, Wildlife and Parks. Bozeman, MT. 53 p.

Lyon, L. J., M. H. Huff, E. S. Telfer, D. S. Schreiner and J. K. Smith. 2000. Chapter 4: Fire effects on animal populations. In: Smith, J. K., ed. 2000. Wildland fire in ecosystems: effects of fire on fauna. Gen. Tech. Rep. RMRS-GTR-42_Vol. 1. Ogden, UT. USDA Forest Service, Rocky Mountain Research Station. 83 p.

Mackie, R.J, D.F. Pac, K.L. Hamlin and G.L. Dusek. 1998. Ecology and Management of Mule Deer and White-tailed Deer in Montana. Montana Fish Wildlife and Parks, Wildlife Division, Helena, Montana. Federal Aid Project W-120-R.

Mackie, R.J., J.G. Kie, D.F. Pac, K.L. Hamlin. 2003. Mule Deer. Chapter 43. *In:* Wild Mammals of North America, Biology, Management, and Conservation. Second Edition. G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, Eds. The Johns Hopkins University Press. Baltimore and London.

Peek, J.M. 2003. Wapiti. Chapter 42. *In:* Wild Mammals of North America, Biology, Management, and Conservation. Second Edition.
G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, Eds. The Johns Hopkins University Press. Baltimore and London.

Stevens, D.R. 1970. Winter ecology of moose in the Gallatin Mountains, Montana. Journal of Wildlife Management, Vol. 34, No. 1, January 1970.

Thomas, J.W. 1979. Wildlife Habitats in Managed Forests - the Blue Mountains of Oregon and Washington. Agriculture Handbook No. 553. USDA Forest Service.

Tyers, D.B. 2003. Winter Ecology of Moose on the Northern Yellowstone Winter Range.
PhD. Dissertation, Montana State University. Bozeman, Montana.

USDA Forest Service. 1987. Gallatin National Forest Plan.

USDA Forest Service. 2007. Gallatin National Forest Travel Management Plan FEIS.

Gray Wolf

Dixon, B. 2007c. Gray Wolf Report (revised May 9, 2007). Bozeman, MT. pp. 6.

Claar, J., N. Anderson, D. Boyd, B. Conrad, G. Hickman, R. Hompesch, G. Olson, H. Ihsle Pac, T. Wittinger, and H. Youmans. 1999. Carnivores. Pages 7.1-7.63 *in* G. Joslin and H. Youmans, coordinators. Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. The Wildlife Society, Helena, Montana, USA. (www.montanatws.org)

Fritts, S., R. Stephenson, R. Hayes, and L. Boitani. 2003. Wolves and Humans. Pages 289-316 *in* L. D. Mech, and L. Boitani, editors. Wolves: Behavior, Ecology, and Conservation. University of Chicago Press, Chicago, Illinois, USA.

Grizzly Bear

Blanchard, B. 1983. Grizzly bear habitat relationships in the Yellowstone Area. Int. Conf. Bear Res. and Manage. 5:118-123. *Cited in:* IGBC 1987:114-115.

Blanchard, B. and R. R. Knight. 1996. Effects of wildfire on grizzly bear movements and food habits. *Cited in:* Smith 2000:56.

Dixon, B. 1997. Cumulative effects modeling for grizzly bears in the Greater Yellowstone Ecosystem. Masters Thesis. Montana State University, Bozeman, Montana. 139 pp.

Dixon, B. 2007d. Grizzly Bear Report (revised May 9, 2007). Bozeman, MT. pp. 13.

Elgmork, K. 1978. Human impact on a brown bear population. Biol. Conserv. 13(2):81-103. *Cited in:* IGBC 1987:145

Erickson, A. W. 1977. Cabinet Mountains grizzly bear management study. USDA Forest Service contract no. 262.46. 25 p. *Cited in:* IGBC 1987:145

ICST 2003. Final Conservation Strategy for the Grizzly Bear in the Yellowstone Ecosystem. Developed by the Interagency Conservation Strategy Team. March 2003.

IGBC 1987. Grizzly Bear Compendium. Sponsored by the Interagency Grizzly Bear Committee. 1987.

Jonkel, C. 1982. Five year summary report: Border grizzly project., Univ. Mont., Missoula. Spec. Rep. No. 60. 77 pp. *Cited in:* IGBC 1987:145

Lyon, L. J., M. H. Huff, E. S. Telfer, D. S. Schreiner and J. K. Smith. 2000. Chapter 4: Fire effects on animal populations. *In:* Smith 2000.

Schwartz, C.C., M.A. Haroldson, K.A. Gunther, and D. Moody. 2002. Distribution of grizzly bears in the Greater Yellowstone Ecosystem, 1990-2000. Ursus 13:156-162.

Smith, J. K., ed. 2000. Wildland fire in ecosystems: effects of fire on fauna. Gen. Tech. Rep. RMRS-GTR-42_Vol. 1. Ogden, UT. USDA Forest Service, Rocky Mountain Research Station. 83 p.

USDA Forest Service. 1987. Gallatin National Forest Plan. Bozeman, Montana.

USDI Fish and Wildlife Service. 1993. Grizzly bear recovery plan. Missoula, Montana. 181 pp.

Inventoried Roadless

Cary, D. 2007. Inventoried Roadless Report (May 4, 2007). Bozeman, MT. pp. 13.

USDA Forest Service, *Final Environmental Impact Statement*, *Gallatin National Forest Plan, September 1987, pages C-31-42*

USDA Forest Service, *36 CFR Part 294, Special Areas;Roadless Area Conservation; Final Rule, 2001*

Gallatin National Forest GIS layer, *Roadless Area Inventory*

USDA Forest Service, *Roadless Area Conservation-Final Rule, 36 CFR 294, 2001*

Cumulative Effects Analysis for Roadless Issue, *D. Cary, March 2007*

Spatial Boundary Map for Roadless Issue, *D. Cary, March 2007*

Lynx

Literature Cited

Hodges, K. E. 2000. Ecology of snowshoe hares in southern boreal and montane forests. Chapter 7. *In:* Ruggiero, L. F., K. B. Aubry, S. W. Buskirk 2000. Ecology and conservation of lynx in the United States. University Press of Colorado, Boulder. 480 p.

Ruediger, B., J. Claar, S. Gniadek, B. Holt, L. Lewis, S. Mighton, B. Naney, G. Patton, T. Rinaldi, J. Trick, A. Vandehey, F. Wahl, N. Warren, D. Wenger and A. Williamson.

2000. Canada lynx conservation assessment and strategy. Forest Service Publication #R1-00-53, Missoula, MT. 142 pp.

USDA Forest Service. 1991. Forest and Rangeland Birds of the United States. Natural History and Habitat Use. Agriculture Handbook 688. 625 pp.

USDA Forest Service. 2007. Northern Rockies Lynx Management Direction Record of Decision. March 2007.

Migratory Birds

Dixon, B. 2007e. Migratory Birds Report (revised May 9, 2007). Bozeman, MT. pp. 8.

Dobkin, D.S. 1992. Neotropical migrant landbirds in the Northern Rockies and Great Plains: a handbook for conservation and management. US Forest Service, Northern Region, Publication No. R1-93-34, Missoula, Montana.

Duncan, J.R. and P.H. Hayward. 1994. Review of Technical Knowledge: Great Gray Owls. Chapter 14 *In:* Hayward, G. D. and J. Verner, tech. eds.1994. Flammulated, boreal and great gray owls in the United States: A technical conservation assessment. USDA Forest Service Gen. Tech. Rep. RM-253. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. Hejl, S. J. 1994. Human-induced changes in bird populations in coniferous forests in western North America during the past 100 years. *Cited in:* Hutto and Young 1999.

Hutto, R.L. and J.S. Young. 1999. Habitat relationships of landbirds in the Northern Region, USDA Forest Service. Gen. Tech. Rep. RMRS-GTR-32. Rocky Mountain Research Station, Fort Collins, Colorado.

Knight, R.L. and K.J. Gutzwiller eds. 1995. Wildlife and Recreationists. Coexistence through management and research. Island Press, Washington, DC.

Mikkola, H. 1983. Owls of Europe. Buteo Books, Vermillion, South Dakota. *Cited in:* Duncan and Hayward 1994:165

Nero, R.W. 1980. The Great Gray Owl - phantom of the northern forest. Smithsonian Institution Press, Washington, DC. *Cited in:* Duncan and Hayward 1994:165

Peterson, J.G. 1995. Ecological implications of sagebrush manipulation. Wildlife Management Division, Montana Fish, Wildlife and Parks. Federal Aid in Wildlife Restoration Project W-101-R-2.

Rich, A.C., D.S. Dobkin and L.J. Niles. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conservation Biology. Volume 8, No. 4, pp. 1109-1120.

Saab, V. A., C. E. Bock, T. D. Rich and D.S. Dobkin. 1995. Livestock grazing effects in western North America. *In:* Martin, T.E. and D.M. Finch, eds. Ecology and management of Neotropical migratory birds: a synthesis and review of critical Issues. New York, NY: Oxford University Press:311:353.

Tewksbury, J.J., a.E. Black, N. Nur, V.A. Saab, B.D. Logan and D.S. Dobkin 2002. Effects of anthropogenic fragmentation and livestock grazing on western riparian bird communities. Studies in Avian Biology No. 25:158-202

USDA Forest Service, 1991. Forest and Rangeland Birds of the United States. Natural History and Habitat Use. Agriculture Handbook 688.

Winter, J. 1986. Status, distribution and ecology of the Great Gray Owl (*Strix nebulosa*) in California. Thesis. San Francisco State University, San Francisco, CA. *Cited in:* Duncan and Hayward 1994:165

Recreation

Cary, D. 2007a. Recreation Report (5/4/2007). Bozeman, MT. pp. 8

USDA Forest Service, *Gallatin National Forest Plan, pages II-2-3, 1987*

USDA Forest Service, *Gallatin National Forest ROS Inventory Map, February 1986*

Cumulative Effects Analysis for Recreation Issue, *D. Cary, March 2007*

Spatial Boundary Map for Recreation Issue, *D. Cary, March 2007*

Scenery

Ruchman, J. 2007. Scenery Report and photos. Bozeman, MT.

USDA, FS, Northern Region, "Visual Character Types & Variety Class Description" R1-80-11, prepared as an integral part of the National Forest landscape management in Region 1 of the USDA – Forest Service

USDA FS, Intermountain Forest and Range Experiment Station, Ogden, UT 84401, General Technical Report, INT-158, December 1983 "fire and Vegetative Trends in the Northern Rockies: Interpretations from 1871- 1982 Photographs" by George E. Gruell, page 92

Title 36 of the Code of Federal Regulations, Part 219, Subpart A, National Forest System Land and Resource Management Planning (36CFR part 219, subpart A)

Forest Service Manual Chapter 2380.11a - 2380.11b, Resource Management Planning and Environmental Analysis and Disclosure

USDA Forest Service, 1974 National Forest Landscape Management, Vol. 2, Ch. 1, Ag Handbook #462

Landscape Aesthetics: A Handbook for Scenery Management, USDA Forest Service, Agriculture Handbook Number 701, December 1995

Sensitive Wildlife and Plant Species

Clark, T.W., A.H. Harvey, R.D. Dorn, D.L. Genter, and C. Groves, eds. 1989. Rare, sensitive and threatened species of the Greater Yellowstone Ecosystem. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy, and Mountain West Environmental Services. 153 pp.

Dixon, B. 2007f. Sensitive Wildlife and Plant Species Report (revised March 6, 2007). Bozeman, MT. pp. 3.

Finch, D. M. 1992. Threatened, endangered and vulnerable species of terrestrial vertebrates in the Rocky Mountain Region. USDA Forest Service, Gen. Tech. Rep. RM-215. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 37 p.

Hamilton, W.J., Jr. and J.O. Whitaker Jr. 1979. Mammals of the eastern United States, second edition. Cornell University Press, Ltd, London, UK. *Cited in:* IDFG 1995:7

IDFG 1995. Townsend's big-eared bat habitat conservation assessment and conservation strategy. Idaho Department of Fish and Game, Idaho Department of Parks and Recreation, Bureau of Land Management, Regions 1 and 4 of the U. S. Forest Service, and U. S. Fish and Wildlife Service. Unpublished doc. 45 p.

Kunz, T. H., and R. A. Martin. 1982. *Plecotus townsendii.* Mammalian Species No. 175. Amer. Soc. Mamm. 6 pp. *Cited in:* Finch 1992:17.

McCallum, D. A. 1994. Review of Technical Knowledge: Flammulated Owls. *In:* Hayward, G. D. and J. Verner, tech. eds.1994. Flammulated, boreal and great gray owls in the United States: A technical conservation assessment. USDA Forest Service Gen. Tech. Rep. RM-253. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 214 p.

USDA Forest Service, 1989. Caring for our Natural Community. Region 1 Threatened, Endangered and Sensitive Species Program. US Government Printing Office: 1989-691-969.

Soil Quality

Debano, Leonard, Daniel Neary, and Peter Ffolliott. 1998. Fire's effects on ecosystems. John Wiley & Sons, NY.

Davis, C. E. and H. F. Shovic. 1996. Soil Survey of Gallatin Forest, Montana. Gallatin National Forest, Bozeman, MT. Maps 106, 110 and map unit descriptions.

Keunnen, L, et.al., May 2000. Soil quality monitoring: a review of methods and trends in the Northern Region. USDA, Forest Service, Northern Region. (PF, F-12)

Page-Dumroese, Deborah, M. Jurgensen, A. Abbott, T. Rice, J. Tirocke, S. Farley, and S. Dehart. 2006. Monitoring changes in soil quality from post-fire logging in the inland Northwest.. USDA Forest Services Proceedings RMRS-P-41, Rocky Mountain Research Station, Moscow, Idaho.

Philipek, Frances M.1985. Over-snow logging: analysis of impacts to lithic scatters, Studies in cultural resource management #5. USDA, Forest Service, Pacific Northwest Region.

Pritchett, W. L., 1979. Properties and management of forest soils. John Wiley and Sons, NY. (page 16, 17)

Story, Mark. 2006. Deer Creek Burns – Implementation Monitoring Review. Letter to Big Timber District Ranger, Gallatin N. F., USDA, Forest Service

Story, Mark. 2006b. Baldy Peak Timber Sale Implementation Monitoring Review June 30, 2006. Letter to Big Timber District Ranger, Gallatin N. F., USDA, Forest Service

Shovic, H. 2007. Soils Report. Bozeman, MT. pp.

Shovic, Henry. 2006, Soil Monitoring Report. Document for Gallatin National Forest, Box 130, Bozeman, MT.

Shovic, Henry. 2006b. Smith Creek Fuels Reduction Soil Issue. Analysis Document for Gallatin National Forest, Dec 4, 2006, Box 130, Bozeman, MT.

Shovic, Henry. 2003. Darroch Eagle Timber Sale Proposal Evaluation. Memo to Gallatin National Forest, Dec 5, 2003, Box 130, Bozeman, MT.

Shovic, Henry. 1999. Review of Pole Gulch Timber Sale Soil Impacts. Memo to Gallatin National Forest, Aug. 18, 1999, Box 130, Bozeman, MT.

Shovic, H. F. and K. Birkeland. 1992. Gallatin National Forest 1991 soil monitoring program: summary report. USDA Forest Service, Gallatin National Forest.

Shovic, H. F. and G. Widner. 1991. Gallatin National Forest 1990 soil monitoring program: summary report. USDA Forest Service, Gallatin National Forest.

USDA Forest Service. 1999. FSM 2500- Watershed and Air Management, R-1 Supplement 2500-99-1, 2554- Soil Quality Monitoring. 6 pp.

USDA, Forest Service. 1987. Gallatin National Forest Plan, pp. II-1, II-24.

Water Quality

Cline R., G. Cole, W. Megahan, R. Patten, J. Potyondy. 1981. Guide for Predicting Sediment Yields from Forested Watersheds. US Forest Service, R1/R4. pp 7-20.

Cowardin L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. Washington, DC.

City of Bozeman. 2006. Water Facility Plan. http://www.bozeman.net/bozeman/engineering/documents/Water_Facility_Plan.pdf p 693.

Montana DNRC 2006. Best Management Practices for Forestry in Montana. Missoula, MT.

Rosgen, D.L., 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO

Story, M. 2007b. Water Quality Report (revised 5/14/2007). Bozeman, MT. p. 21.

Story, M. 2007c. Water Quality Cumulative Effect Checklist. Bozeman, MT. p. 7.

USFS, 1994, BMP Review, Hyalite Wildlife Burn, 7/18/1994. Bozeman, Montana.

USFS, 1996, BMP Review, Bozeman Creek and Storm Castle Burn, 8/1/1996. Bozeman, Montana.

USFS, 1998. Hyalite, West Hyalite, and South Cottonwood Grazing Allotment, Environmental Assessment. 12/21/1998. Bozeman, Montana.

USFS 2003. Bozeman Creek Risk Assessment. 6/2003. p 19, Bozeman, MT.

USFS 2005. Karst Burn – Implementation Monitoring Review. 7/1/05, p. 5, Bozeman, MT.

USFS 2006. Deer Creek Burn D6, Gallatin Canyon North– Implementation Monitoring Review 8/7/06. p. 11, Bozeman, MT.

Weeds

Clark, Janet 2003. Invasive plant prevention guidelines. Center for Invasive Plant Management. www.weedcenter.org.

Councilman, J. 2007. Noxious Weed Report and Appendices (revised May 25, 2007). Bozeman, MT.

Forman, Richard T. T. Daniel Sperling, John A. Bissonette, Anthony P. Clevenger, Carol D. Cutshall, Virginia H. Dale, Lenore Fahrig, Robert France, Charles R. Goldman, Kevin Heanue, Julia A. Jones, Fredrick J. Swanson, Thomas Turrentine, Thomas C. Winter. 2003. Road ecology science and solutions. Island Press.

Gelbard, Jonathan L., and Susan Harrison. 2002. Roadless habitat as refuges for native grasslands: interactions with soil, aspect, and grazing. Ecological Applications: Vol. 13, No. 2, pp. 404–415.

Gillham, John. 2001. Weed invasion susceptibility prediction modeler for ArcView 3.2. WISP MODELER. University of Wyoming.

Mantas, Maria. 2003. Evaluating risk to native plant communities from selected exotic plant species. USDA Forest Service and the Nature Conservancy of Montana.

Montana. 2005. Montana weed management plan.

Rew, Lisa, Frank Doughery 2007. Non-native Invasive Species Risk Assessment Model. Montana State University. Unpublished data.

Sheley, Roger L., Janet K. Petroff. 1999. Biology and management of noxious rangeland weeds. Oregon State University Press.

Sheley, Roger l. Bret E. Olsen, Carla Hoopes. 2005. Impacts of noxious weeds. Department of Animal and Range Sciences, Montana State University, Bozeman, MT.

Thysell, David R., and Andrew B. Carey. 2001. Manipulation of density of *Pseudotsuga menziesii* canopies: preliminary effects on understory vegetation. Can. J. For. Res. Vol. 31.

USDA Forest Service. 2001. Guide to noxious weed prevention practices.

USDA Forest Service. 2006. Fire Effects Information System. http://www.fs.fed.us/database/feis/index.html

USDA Forest Service. 2004. National Strategy and Implementation Plan for Invasive Species Management.

Vasievich, Mike. 1998. Quick-Silver project analysis tool. USDA Forest Service.

Wolverine and Pine Marten

Personal Communication Cited

Anderson, Neil. Wildlife Biologist, Montana Fish, Wildlife and Parks, Bozeman, Montana

Inman, Robert. Research Biologist, Wildlife Conservation Society, Ennis, Montana

Leddy, Paige. Law Enforcement Officer, Bozeman Ranger District, USDA Forest Service, Bozeman, Montana

Literature Cited

Banci, V. 1994. Wolverine. Chapter 5 *In:* Ruggiero, L. F., K. B. Aubry, S.W. Buskirk, L. J. Lyon and W. J. Zielinski, tech. eds. 1994. The scientific basis for conserving forest carnivores American marten, fisher, lynx and wolverine in the western United States. USDA Forest Service Gen. Tech. Rep. RM-254. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 184 p.

Buskirk, S. W. and L.F. Ruggiero. 1994. Marten. Chapter 2 *In:* Ruggiero, L. F., K. B. Aubry, S.W. Buskirk, L. J. Lyon and W. J. Zielinski, tech. eds. 1994. The scientific basis for conserving forest carnivores American marten, fisher, lynx and wolverine in the western United States. USDA Forest Service Gen. Tech. Rep. RM-254. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 184 p.

Coffin, K., C.Fager, Q. Kujala, L. Irby, and R. Douglas. 2002. Winter ecology of American Marten in southwestern Montana. Montana Fish, Wildlife and Parks, Wildlife Division, Technical Bulletin. Helena, Montana. 54 pp.

Copeland, J. 1996. Biology of the wolverine in central Idaho. Masters Thesis, University of Idaho.

Copeland, J. and J. Whitman 2003. Wolverine (*Gulo gulo*). Chapter 32 *In:* Wild Mammals of North America, Biology, Management and Conservation. Second Edition. Edited by G. A. Feldhamer, B.C. Thompson and J. A. Chapman. The Johns Hopkins University Press. Baltimore and London.

Dixon, B. 2007g. Wolverine and Marten Report (revised 5/9/2007). Bozeman, MT. pp. 14.

Hash, H.S. 1987. Wolverine. *In:* Novak, M.; Baker, J.A.; Obbard, M.E.; comps. eds. Wild furbearer management and conservation in North America. Toronto: Ontario Ministry of Natural Resources: 575-585. Chapter 43.

Hornocker, M.G., and H. S. Hash. 1981. Ecology of the wolverine in northwestern Montana. Canadian Journal of Zoology. 59:1286-1301.

Inman, K.H.; R.M. Inman; R.R. Wigglesworth; A.J. McCue; B.L. Brock; J.D. Rieck and W. Harrower. 2003. Greater Yellowstone Wolverine Study. Cumulative Progress Report, December 2003. Wildlife Conservation Society - North America Program.

Knight, R.L. and K.J. Gutzwiller. 1995. Wildlife and recreationists. Coexistence through management and research. Island Press. Washington, DC; Covelo, CA.

Magoun, A.J. and J.P. Copeland. 1998. Characteristics of wolverine reproductive den sites. J. Wildl. Manage. 62(4):1313-1320.

Pilliod, D.S, E.L. Bull, J.L. Hayes, and B.C. Wales. 2006. Wildlife and invertebrate responses to fuel reduction treatments in dry coniferous forests of the Western United States: a synthesis. Gen. Tech. Rep. RMRS-GTR-173. Fort Collins, CO. USDA Forest Service, Rocky Mountain Research Station. 34 pp.

Rowland, M.M.; M.J. Wisdom; D.H. Johnson; B.C. Wales; J.P. Copeland and F.B. Edelmann. 2003. Evaluation of landscape models for wolverines in the Interior Northwest, United States of America. J. Mammal 84(1):92-105.

APPENDIX A. Detailed Description of Treatments

Table 1: Detailed Description of Treatments

Existing condition of the vegetation	**Desired Future Condition of the Vegetation**	**Implementation Method Proposed**	**Resulting Fuel Condition**
Generally open grassland or transition forest /grassland		**Broadcast Burning (BB)**	
Predominantly grass with less than 40% crown cover with trees	**Maintain these as open habitats on the landscape.** Spring or fall burning. Strive for approximately 40-60% of the area to be black after burning.	Broadcast burning.	Maintain Fuel Model 2
Forest with small trees less than 6" in diameter		***Mechanical cutting of Small trees (PCT)***	
These are areas with past harvest in the upper slopes and divide between Bozeman Creek and Hyalite Creek. There may be commercial products in some of the stands.	Thin to *8 trees per acre or approximately 15-20 feet between trees. These areas can be managed in a clumpy fashion with break in the fuel continuity between clumps. Fuel loading: 10-15 T/ac. ≥ 3 "; 5 T/ac. < 3"; Slash height < 1.5 – 2.0 ft.	Small tree thinning. (PCT) Handpile and burn. Many fuel treatment options are available depending on products and market. Mechanical processing may be most efficient as far as economics and production. Cutting with chainsaws, hand pile and burning may be the most costly and	Fuel Model 8 or 184 Elevated canopy base height Reduced canopy bulk density. Reduced canopy closure. Reduced surface and

Existing condition of the vegetation	Desired Future Condition of the Vegetation	Implementation Method Proposed	Resulting Fuel Condition
		labor intensive. Whole tree yarding, selling post and poles, selling chips for pulp or hog fuel are some options. Much of the same mechanized equipment as described above in CT/MP could also be utilized. Other machines are available that can chop, crush and shred otherwise un-merchantable material to reduce fuels. Again follow up burning is desirable. Limit the treatment to areas that can be reached from the existing roads.	ladder fuels.
Forest Types with trees generally over 6" in diameter.		**Commercial thin (CT)**	
DF 13 or Predominantly Douglas fir trees with lodgepole pine, alpine fire or spruce Trees over 6 inches in diameter at dbh or 4-1/2 feet above the ground. LPDF13 or Mixed species	Thin to 80-100 ft basal area. Spacing - 18-25 ft. between boles or more to achieve 10-15 ft. crown separation. Leave 35%-50% of	Less than 35% slope = ground based harvest system More than 35% slope either cable or helicopter logging system.	Fuel Model 8 or 184 Elevated canopy base height Reduced canopy bulk

Existing condition of the vegetation	Desired Future Condition of the Vegetation	Implementation Method Proposed	Resulting Fuel Condition
composition Douglas Fir and Lodgepole Pine generally over 6" dbh Canopy closure - dense > 70% shade from the dominant tree class	the overstory canopy. Fuel loading: 10-15 T/ac. ≥ 3 "; 5 T/ac. < 3"; Slash height < 1.5 – 2.0 ft. Forest stands with insect and disease infestation could have a patchy appearance to select the healthier trees to remain on site.	Small trees would be slashed and treated with fuels or removed from the site with methods such as chipping. Remove natural and activity related fuels where fuel loads exceed the desired fuel loading using various methods such as: whole tree yard; yard unmerchantable material, understory burn or jackpot burn or handpile and burn.	density. Reduced canopy closure. Reduced surface and ladder fuels.
DF12 – same as above except the canopy closure ranges from 40-69% which means there are fewer large trees to remove but possible more small trees or ladder fuels. DF11- canopy closure 11-39% species mix is the predominately Douglas fire.	Same as above.	Same as above or possibly underburn only. Underburn only	Same as above
LP 13 – Predominantly Lodgepole Pine trees with alpine fire or spruce Trees over 6 inches in diameter at dbh or 4-1/2 feet above the ground.	Thin: Spacing, 15-18 ft. between boles or more to achieve 10-15 ft. crown separation.	Less than 35% slope = ground based harvest system More than 35% slope either cable or	Same as above.

Existing condition of the vegetation	Desired Future Condition of the Vegetation	Implementation Method Proposed	Resulting Fuel Condition
Canopy closure - dense > 70% shaded from the dominant tree class **LP12 –** same as above except canopy closure 40-69%. **LP11** - same as above except canopy closure 10-39%.	Stands with mountain pile beetle or ≥ 40% mistletoe affected would leave 10-20% of the overstory canopy in clumps. Allow for openings for natural regeneration; 70- 90-ft basal area. Leave 50% overstory canopy. The thinning could be uniform or patchy in appearance depending upon health of the residual stand and visual considerations. Fuel loading: 10-15 T/ac. ≥ 3 "; 5 T/ac. < 3"; Slash height < 1.5 – 2.0 ft. **LPP treatments in general:** whether healthy or not – healthy maybe leave 10-20% overstory canopy because of it's juxtaposition w/ other treatments, or critical position (topography) in reducing fire behavior and effects to other adjacent stands; it's ability to act as a fuel break.	helicopter logging system. Small trees would be slashed and treated with fuels or removed from the site with methods such as chipping. Remove natural and activity related fuels where fuel loads exceed the desired fuel loading using various methods such as: whole tree yard; yard unmerchantable material, understory burn or jackpot burn or handpile and burn.	

Existing condition of the vegetation	Desired Future Condition of the Vegetation	Implementation Method Proposed	Resulting Fuel Condition
SAF – Subalpine fir forest usually has a Lodgepole Pine component. Most LPP is dead or has a high mistletoe infection rate with high fuel loading.	Treat if critical area to fuelbreak or to change fire behavior, or unhealthy. In heavily diseased stands, leave 10-20% overstory canopy in clumps. Where healthy and critical to Fire behavior and effects try the clump thinning. Leave 60-80 ft ba.; which leaves 25-50% of stand. Fuel loading: 10-15 T/ac. ≥ 3 "; 5 T/ac. < 3"; Slash height < 1.5 – 2.0 ft.	Less than 35% slope = ground based harvest system More than 35% slope either cable or helicopter logging system. Small trees would be slashed and treated with fuels or removed from the site with methods such as chipping. Remove natural and activity related fuels where fuel loads exceed the desired fuel loading using various methods such as: whole tree yard; yard unmerchantable material, understory burn or jackpot burn or handpile and burn.	Same as above.

Unit Number	Treatment Acres By Unit By Alternative			
	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1	CT 42	CT 42	BB 42	CT 42
2	--	BB 214	--	CT 18
3	BB 681	BB 681	BB 681	BB 681
4	CT 195	CT 195	CT BB	CT 195
5	--	CT 80	--	PCT 80
6	CT 230	CT 269	BB 228	CT 269
7	CT 135	CT 135	BB 135	CT 135
8	CT 10	CT 91	BB 81	CT 81
9	CT 67	CT 67	--	CT 67
10	CT 19	CT 128	BB 13	CT 128
11	CT 103	CT 103	BB 69	CT 103
12	CT 83	CT 83	BB 33	CT 83
13	CT 234	CT 234	BB 143	CT 234
14	--	CT 110	--	CT 110
15	--	CT 165	BB 165	CT 91
16	CT 208	CT 208	BB 54	CT 208
17	CT 48	CT 48	BB 48	CT 56
18	--	CT 106	BB 71	CT 106
19	--	CT 168	BB 168	CT 168
20	--	CT 241	--	CT 241
21	--	CT 249	BB 240	CT 224
22	CT 426	CT 426	BB 392	CT 547
23	--	--	BB 60	--
24	BB 129	BB 129	BB 124	--

Unit Number	Treatment Acres By Unit By Alternative			
	Alternative 2	Alternative 3	Alternative 4	Alternative 5
25	--	BB 250	BB 79	CT 48
26	CT 119	CT 119	PCT 114	CT 119
27	--	CT 125	--	CT 125
28	CT 76	CT 76	BB 76	CT 76
29	CT 142	CT 142	BB 33	CT 142
30	--	CT 41	--	CT 41
31	CT 48	CT 48	--	--
32	PCT 574	PCT 574	PCT 574	PCT 574
33	PCT 543	PCT 543	PCT 543	PCT 535
34	--	--	BB 146	--
35	--	--	BB 466	--
36	--	--	BB 98	CT 137
37	--	--	--	CT 144
38	--	--	--	CT 92
39	--	--	--	CT 153
40	--	--	--	BB 260
Acreage Subtotal by Treatment	CT = 2,200 ac. PCT=1,150 ac. BB= 850 ac.	CT= 3,900 ac. PCT=1,150 ac. BB= 1,100 ac.	CT = 0 ac. PCT = 1,250 ac. BB = 3850 ac	CT= 3,700 ac. PCT= 1,200 ac. BB = 950 ac.
Temporary Road to Be Constructed	7.2 miles	13.5 miles	0 miles	6.9 miles

Table 2: Bozeman Municipal Watershed Alternative 2

Alternative 2					
Unit Number	Acres by Logging Method				
	skyline	heli/cable	helicopter	tractor	total
321	0	0	42	0	42
334	0	0	188	0	188
347	0	0	135	0	135
358	0	0	10	0	10
369	0	0	66	0	66
1370	0	0	19	0	19
1381	1	0	102	0	103
1392	59	0	11	13	83
1403	125	0	19	74	218
16	56	0	3	149	208
17	0	0	48	0	48
22	230	0	121	76	427
26	21	0	0	98	119
28	40	6	30	0	76
29	28	78	3	27	136
31	19	0	29	0	48
total	579	84	826	437	1926

Table 3 Bozeman Municipal Watershed Alternative 3

Alternative 3						
Unit Number	Acres By Logging Method					
	skyline	heli/cable	heli/tractor	helicopter	tractor	total
1	0	0	0	42	0	42
2	0	0	0	218	0	218
4	0	0	0	188	0	188
5	0	0	0	81	0	81
7	0	0	0	137	0	137
8	0	0	0	91	0	91
9	0	0	0	64	0	64
10	0	0	0	128	0	128
11	1	0	0	102	0	103
12	59	0	0	11	13	83
13	142	0	0	0	94	236
14	60	0	0	0	49	109
15	0	49	46	58	16	169
16	56	0	0	3	149	208
18	25	0	0	48	0	73
19	108	0	0	80	60	248
20	145	0	0	73	22	240

Alternative 3						
Unit Number	Acres By Logging Method					
	skyline	heli/cable	heli/tractor	helicopter	tractor	total
21	17	5	0	126	86	234
22	230	0	0	121	76	427
26	21	0	0	0	98	119
27	104	11	0	0	0	115
28	70	6	0	0	0	76
29	35	81	0	0	27	143
30	38	3	0	0	0	41
31	19	0	0	29	0	48
total	1130	155	46	1600	690	3621

Table 4: Bozeman Municipal Watershed Alternative 5

Alternative 5						
Unit number	Acres By Logging Method					
	skyline	heli/cable	heli/tractor	helicopter	tractor	total
1	0	0	0	42	0	42
2	0	0	0	18	0	18
3	0	0	0	0	0	0
4	0	0	0	188	0	188
5	0	0	0	0	0	0
6	0	0	0	9	0	9
7	0	0	0	134	0	134
8	0	0	0	81	0	81
9	0	0	0	67	0	67
10	0	0	0	129	0	129
11	0	0	0	98	0	98
12	0	0	0	73	0	73
13	58	0	0	131	91	281
14	0	0	0	74	35	109
15	0	0	0	75	17	92
16	56	0	0	3	149	208
17	25	0	0	55	0	81
18	25	0	0	80	0	105
19	0	0	0	0	0	0
20	77	0	0	108	0	185
21	8	0	0	131	86	224
22	158	0	0	329	58	544
25	0	0	0	0	39	39
26	0	0	0	0	96	96
27	0	0	0	126	0	126
28	36	0	0	40	0	76

Alternative 5

Unit number	Acres By Logging Method					
	skyline	heli/cable	heli/tractor	helicopter	tractor	total
29	0	0	0	115	27	142
30	0	0	0	42	0	42
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	26	26
36	0	0	0	121	0	121
37	0	0	0	127	0	127
38	0	0	0	92	0	92
39	4	0	0	0	150	154
total	447	0	0	2487	774	3708

APPENDIX B Best Management Practices

Soil Protection Best Management Practices
Practice 15.26-2007 Gallatin National Forest Soil Productivity Protection Best Management Practice (Gallatin Soil BMP)

OBJECTIVE: To protect soil productivity in tractor harvest operations on the Gallatin National Forest
EFFECTIVENESS: High
IMPLEMENTATION:

Require a systematic skid trail pattern during logging.

Use ground-based harvest systems only on slopes having sustained grades less than 35 percent.

Maintain an average of at least 100 feet between skid trails, and allow no tractors off these trails at any time, with the exception of designated landings and system roads.

The above do not apply if operating on soils with at least 8 inches of snow cover, or over soils frozen to at least 4 inches in depth. Winter logging has a negligible effect on soil or vegetation cover.

Allow no mechanical site preparation equipment off established skid roads unless the soil is frozen or snow-covered as discussed above, or where a continuous slash mat is at least 12 inches deep; with exception of feller/bunchers. This equipment type should minimize repeat passes over the same ground.

Allow ground-disturbing operations off designated skid trails only when the soil is dry (not moldable in the hand).

Monitoring Requirements

To verify the predictions used in this analysis, and to provide information for future work, soil productivity monitoring should be undertaken on all harvest units using ground-based systems. This should follow the current version of the Northern Region Soil Quality Monitoring Protocol (USDA Forest Service, 2007, or the current version at the time of sampling and authorized by Tidwell, 2007). It should be completed within two years of Activity Area completion. To verify the above predictions and estimated effects in burn units, and to provide information for future work, monitoring should be undertaken on a representative sample of burn units.

BEST MANAGEMENT PRACTICES FOR FORESTRY IN MONTANA
January 2004

I. DEFINITIONS

1. "Hazardous or toxic material" means substances which by their nature are dangerous to handle or dispose of, or a potential environmental contaminant, and includes petroleum products, pesticides, herbicides, chemicals, and biological wastes.

2. "Stream," as defined in 77-5-302(7), MCA, means a natural water course of perceptible extent that has a generally sandy or rocky bottom or definite banks and that confines and conducts continuously or intermittently flowing water.

3. "Streamside Management Zone (SMZ)" or "zone" as defined at 77-5-302(8), MCA means "the stream, lake, or other body of water and an adjacent area of varying width where management practices that might affect wildlife habitat or water quality, fish, or other aquatic resources need to be modified." The streamside management zone encompasses a strip at least 50 feet wide on each side of a stream, lake, or other body of water, measured from the ordinary high water mark, and extends beyond the high water mark to include wetlands and areas that provide additional protection in zones with steep slopes or erosive soils.

4. "Wetlands" mean those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include marshes, swamps, bogs, and similar areas.

5. Adjacent wetlands are wetlands within or adjoining the SMZ boundary. They are regulated under the SMZ law.

6. Isolated wetlands lie within the area of operation, outside of the SMZ boundary, and are not regulated under the SMZ law.

II. STREAMSIDE MANAGEMENT

The Streamside Management Law (77-5-301 through 307 MCA) provides minimum regulatory standards for forest practices in streamside management zones (SMZ). The "Montana Guide to the Streamside Management Zone & Rules" is an excellent information source describing management opportunities and limitations within SMZs.

III. ROADS

A. Planning and Location

1. Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership and foreseeable future uses. Use existing roads, unless use of such roads would cause or aggravate an erosion problem.

2. Review available information and consult with professionals as necessary to help identify erodible soils and unstable areas, and to locate appropriate road surface materials.

3. Fit the road to the topography by locating roads on natural benches and following natural contours. Avoid long, steep road grades and narrow canyons.

4. Locate roads on stable geology, including well-drained soils and rock formations that tend to dip into the slope. Avoid slumps and slide prone areas characterized by steep slopes, highly weathered bedrock, clay beds, concave slopes, hummocky topography, and rock layers that dip parallel to the slope. Avoid wet areas, including moisture laden or unstable toe slopes, seeps, wetlands, wet meadows, and natural drainage channels.

5. Minimize the number of stream crossings and choose stable stream crossing sites.

6. Locate roads to provide access to suitable (relatively flat and well drained) log landing areas to reduce soil disturbance.

B. Design

1. Properly design roads and drainage facilities to prevent potential water quality problems from road construction.

2. Design roads to the minimum standard necessary to accommodate anticipated use and equipment. The need for higher engineering standards can be alleviated through proper road-use management.

3. Design roads to balance cuts and fills or use full bench construction (no fill slope) where stable fill construction is not possible.

4. Design roads to minimize disruption of natural drainage patterns. Vary road grades to reduce concentrated flow in road drainage ditches, culverts, and on fill slopes and road surfaces.

C. Road Drainage

Road Drainage is defined as all applied mechanisms for managing water in a non-stream crossing setting, road surface drainage, and overland flow; ditch relief, cross drains and drain dips).

1. Provide adequate drainage from the surface of all permanent and temporary roads. Use out sloped, in sloped or crowned roads, and install proper drainage features. Space road drainage features so peak flow on road surfaces or in ditches will not exceed capacity.

a. Outsloped roads provide a means of dispersing water in a low energy flow from the road surface. Outsloped roads are appropriate when fill slopes are stable, drainage will not flow directly into stream channels, and transportation safety can be met.

b. For in-sloped roads, plan ditch gradients steep enough, generally greater than 2% but less than 8%, to prevent sediment deposition and ditch erosion. The steeper gradients may be suitable for more stable soils; use the lower gradients for less stable soils.

c. Design and install road surface drainage features at adequate spacing to control erosion; steeper gradients require more frequent drainage features. Properly constructed drain dips can be an economical method of road surface drainage. Construct drain dips deep enough into the subgrade so that traffic will not obliterate them.

2. Design all ephemeral draw culverts with adequate length to allow for road fill width. Minimum culvert size is 15 inch. Install culverts to prevent erosion of fill, seepage and failure as described in V.C.4 and maintain cover for culverts as described in V.C.6.

3. Design all relief culverts with adequate length to allow for road fill width. Protect the inflow end of all relief culverts from plugging and armor if in erodible soil. When necessary construct catch basins with stable side slopes. Unless water flows from two directions, skew ditch relief culverts 20 to 30 degrees toward the inflow from the ditch to help maintain proper function.

4. Where possible, install culverts at the gradient of the original ground slope; otherwise, armor outlets with rock or anchor downspouts to carry water safely across the fill slope.

5. Provide energy dissipaters (rock piles, slash, log chunks, etc.) where necessary to reduce erosion at outlet of drainage features. Crossdrains, culverts, water bars, dips, and other drainage structures should not discharge onto erodible soils or fill slopes without outfall protection.

6. Prevent downslope movement of sediment by using sediment catch basins, drop inlets, changes in road grade, headwalls, or recessed cut slopes.

7. Route road drainage through adequate filtration zones or other sediment-settling structures to ensure sediment doesn’t reach surface water. Install road drainage features above stream crossings to route discharge into filtration zones before entering a stream.

D. Construction (see also Section V on stream crossings)

1. Keep slope stabilization, erosion and sediment control work current with road construction. Install drainage features as part of the construction process, ensuring that drainage structures are fully functional. Complete or stabilize road sections within same operating season.

2. Stabilize erodible, exposed soils by seeding, compacting, riprapping, benching, mulching, or other suitable means.

3. At the toe of potentially erodible fill slopes, particularly near stream channels, pile slash in a row parallel to the road to trap sediment (example, slash filter windrow). When done concurrently with road construction, this is one method that can effectively control sediment movement, and it can also provide an economical way of disposing of roadway slash. Limit the height, width and length of "slash filter windrows" so wildlife movement is not impeded. Sediment fabric fences or other methods may be used if effective.

4. Minimize earthmoving activities when soils appear excessively wet. Do not disturb roadside vegetation more than necessary to maintain slope stability and to serve traffic needs.

5. Construct cut and fill slopes at stable angles to prevent sloughing and other subsequent erosion.

6. Avoid incorporating potentially unstable woody debris in the fill portion of the road prism. Where possible, leave existing rooted trees or shrubs at the toe of the fill slope to stabilize the fill.

7. Consider road surfacing to minimize erosion.

8. Place debris, overburden, and other waste materials associated with construction and maintenance activities in a location to avoid entry into streams. Include these waste areas in soil stabilization planning for the road.

9. Minimize sediment production from borrow pits and gravel sources through proper location, development and reclamation.

10. When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety; avoid disturbing stable road surfaces. Prior to reconstruction of existing roads within the SMZ, refer to the SMZ law. Consider abandoning existing roads when their use would aggravate erosion.

E. Maintenance

1. Grade road surfaces only as often as necessary to maintain a stable running surface and adequate surface drainage.

2. Maintain erosion control features through periodic inspection and maintenance, including cleaning dips and cross drains, repairing ditches, marking culvert inlets to aid in location, and clearing debris from culverts.

3. Avoid cutting the toe of cut slopes when grading roads, pulling ditches, or plowing snow.

4. When plowing snow, provide breaks in snow berm to allow road drainage.

5. Haul all excess material removed by maintenance operations to safe disposal sites and stabilize these sites to prevent erosion. Avoid side casting in locations where erosion will carry materials into a stream.

6. Avoid using roads during wet periods if such use would likely damage the road drainage features. Consider gates, barricades or signs to limit use of roads during spring break up or other wet periods.

7. Upon completion of seasonal operations, ensure that drainage features are fully functional. The road surface should be crowned, outsloped, insloped, or water-barred. Remove berms from the outside edge where runoff is channeled.

8. Leave abandoned roads in a condition that provides adequate drainage without further maintenance. Close these roads to traffic; reseed and/or scarify; and, if necessary, recontour and provide water bars or drain dips.

IV. TIMBER HARVESTING, AND SITE PREPARATION

A. Harvest Design

1. Plan timber harvest in consideration of your management objectives and the following:

a. Soils and erosion hazard identification.
b. Rainfall.
c. Topography.
d. Silvicultural objectives.
e. Critical components (aspect, water courses, landform, etc.).
f. Habitat types.
g. Potential effects on water quality and beneficial water uses.
h. Watershed condition and cumulative effects of multiple timber management activities on water yield and sediment production.
i. Wildlife habitat.

2. Use the logging system that best fits the topography, soil type, and season, while minimizing soil disturbance and economically accomplishing silvicultural objectives.

3. Use the economically feasible yarding system that will minimize road densities.

4. Design and locate skid trails and skidding operations to minimize soil disturbance. Using designated skid trails is one means of limiting site disturbance and soil compaction. Consider the potential for erosion and possible alternative yarding systems prior to planning tractor skidding on steep or unstable slopes.

5. Locate skid trails to avoid concentrating runoff and provide breaks in grade. Locate skid trails and landings away from natural drainage systems and divert runoff to stable areas. Limit the grade of constructed skid trails on geologically unstable, saturated, highly erosive, or easily compacted soils to a maximum of 30%. Use mitigating measures, such as water bars and grass seeding, to reduce erosion on skid trails.

6. Minimize the size and number of landings to accommodate safe, economical operation. Avoid locating landings that require skidding across drainage bottoms.

B. Other Harvesting Activities

1. Tractor skid where compaction, displacement, and erosion will be minimized. Avoid tractor or wheeled skidding on unstable, wet, or easily compacted soils and on slopes that exceed 40% unless operation can be conducted without causing excessive erosion. Avoid skidding with the blade lowered. Suspend leading ends of logs during skidding whenever possible.

2. Avoid operation of wheeled or tracked equipment within isolated wetlands, except when the ground is frozen (see Section VI on winter logging).

3. Use directional felling or alternative skidding systems for harvest operations in isolated wetlands.

4. For each landing, provide and maintain a drainage system to control the dispersal of water and to prevent sediment from entering streams.

5. Insure adequate drainage on skid trails to prevent erosion. On gentle slopes with slight disturbance, a light ground cover of slash, mulch or seed may be sufficient. Appropriate spacing between water bars is dependent on the soil type and slope of the skid trails. Timely implementation is important.

6. When existing vegetation is inadequate to prevent accelerated erosion, apply seed or construct water bars before the next growing season on skid trails, landings and fire trails. A light ground cover of slash or mulch will retard erosion.

C. Slash Treatment and Site Preparation

1. Rapid reforestation of harvested areas is encouraged to reestablish protective vegetation.

2. When treating slash, care should be taken to preserve the surface soil horizon by using appropriate techniques and equipment. Avoid use of dozers with angle blades.

3. Minimize or eliminate elongated exposure of soils up and down the slope during mechanical scarification.

4. Scarify the soil only to the extent necessary to meet the resource management objectives. Some slash and small brush should be left to slow surface runoff, return soil nutrients, and provide shade for seedlings.

5. Carry out brush piling and scarification when soils are frozen or dry enough to minimize compaction and displacement.

6. Carry out scarification on steep slopes in a manner that minimizes erosion. Broadcast burning and/or herbicide application is preferred means for site preparation, especially on slopes greater than 40%.

7. Remove all logging machinery debris to proper disposal site.

8. Limit water quality impacts of prescribed fire by constructing water bars in firelines; not placing slash in drainage features and avoiding intense fires unless needed to meet silvicultural goals. Avoid slash piles in the SMZ when using existing roads for landings.

V. STREAM CROSSINGS

A. Legal Requirements

1. Under the Natural Streambed and Land Preservation Act of 1975 (the "310 law"), any activity that would result in physical alteration or modification of a perennial stream, its bed or immediate banks must be approved in advance by the supervisors of the local conservation district. Permanent or temporary stream crossing structures, fords, rip rapping or other bank stabilization measures, and culvert installations on perennial streams are some of the forestry-related projects subject to 310 permits. Before beginning such a project, the operator must submit a permit application to the conservation district indicating the location, description, and project plans. The evaluation generally includes onsite review, and the permitting process may take up to 60 days.

2. Stream-crossing projects initiated by federal, state or local agencies are subject to approval under the "124 permit" process (administered by the Department of Fish, Wildlife and Parks), rather than the 310 permit.

3. A short-term exemption (3a authorization) from water quality standards is necessary unless waived by the Department of Fish, Wildlife and Parks as a condition of a 310 or 124 permit. Contact the Department of Environmental Quality in Helena at 444-2406 for additional information.

B. Design Considerations (Note: 310 permit required for perennial streams)

1. Cross streams at right angles to the main channel if practical. Adjust the road grade to avoid the concentration of road drainage to stream crossings. Direct drainage flows away from the stream crossing site or into an adequate filter.

2. Avoid unimproved stream crossings. Depending on location, culverts, bridges and stable/reinforced fords may be used.

C. Installation of Stream Crossings (Note: 310 permit required for perennial streams)

1. Minimize stream channel disturbances and related sediment problems during construction of road and installation of stream crossing structures. Do not place erodible material into stream channels. Remove stockpiled material from high water zones. Locate temporary construction bypass roads in locations where the stream course will have minimal disturbance. Time construction activities to protect fisheries and water quality.

2. Design stream-crossings for adequate passage of fish (if present) with minimum impact on water quality. When using culverts to cross small streams, install those culverts to conform to the natural stream bed and slope on all perennial streams and on intermittent streams that support fish or that provides seasonal fish passage. Ensure fish movement is not impeded. Place culverts slightly below normal stream grade to avoid outfall barriers.

3. Do not alter stream channels upstream from culverts, unless necessary to protect fill or to prevent culvert blockage. On stream crossings, design for, at a minimum, the 25-year frequency runoff. Consider oversized pipe when debris loading may pose problems. Ensure sizing provides adequate length to allow for depth of road fill.

4. Install stream-crossing culverts to prevent erosion of fill. Compact the fill material to prevent seepage and failure. Armor the inlet and/or outlet with rock or other suitable material where feasible.

5. Consider dewatering stream crossing sites during culvert installation.

6. Maintain a 1-foot minimum cover for stream-crossing culverts 15 to 36 inches in diameter, and a cover of one-third diameter for larger culverts, to prevent crushing by traffic.

7. Use culverts with a minimum diameter of 15 inches for permanent stream crossings.

D. Existing Stream Crossings

1. Ensure stream crossing culverts have adequate length to allow for road fill width and are maintained to preserve their hydrologic capacity. To prevent erosion of fill, provide or maintain armoring at inlet and/or outlet with rock or other suitable material where feasible. Maintain fill over culvert as described in V.C. 6.

VI. Winter Logging

A. General

1. Consider snow-road construction and winter harvesting in isolated wetlands and other areas with high water tables or soil erosion and compaction hazards.

2. Conduct winter logging operations when the ground is frozen or snow cover is adequate (generally more than one foot) to prevent rutting or displacement of soil. Be prepared to suspend operations if conditions change rapidly, and when the erosion hazard becomes high.

3. Consult with operators experienced in winter logging techniques.

B. Road Construction and Harvesting Considerations

1. For road systems across areas of poor bearing capacity, consider hauling only during frozen periods. During cold weather, plow any snow cover off of the roadway to facilitate deep freezing of the road grade prior to hauling.

2. Before logging, mark existing culvert locations. During and after logging, make sure that all culverts and ditches are open and functional.

3. Use compacted snow for road beds in unroaded, wet or sensitive sites. Construct snow roads for single-entry harvests or for temporary roads.

4. In wet, unfrozen soil areas, use tractors or skidders to compact the snow for skid road locations only when adequate snow depth exists. Avoid steeper areas where frozen skid trails may be subject to erosion the next spring.

5. Return the following summer and build erosion barriers on any trails that are steep enough to erode.

VII. HAZARDOUS SUBSTANCES

A. General

1. Know and comply with regulations governing the storage, handling, application (including licensing of applicators), and disposal of hazardous substances. Follow all label instructions.

2. Develop a contingency plan for hazardous substance spills, including cleanup procedures and notification of the State Department of Environmental Quality.

B. Pesticides and Herbicides

1. Use an integrated approach to weed and pest control, including manual, biological, mechanical, preventive and chemical means.

2. To enhance effectiveness and prevent transport into streams, apply chemicals during appropriate weather conditions (generally calm and dry) and during the optimum time for control of the target pest or weed.